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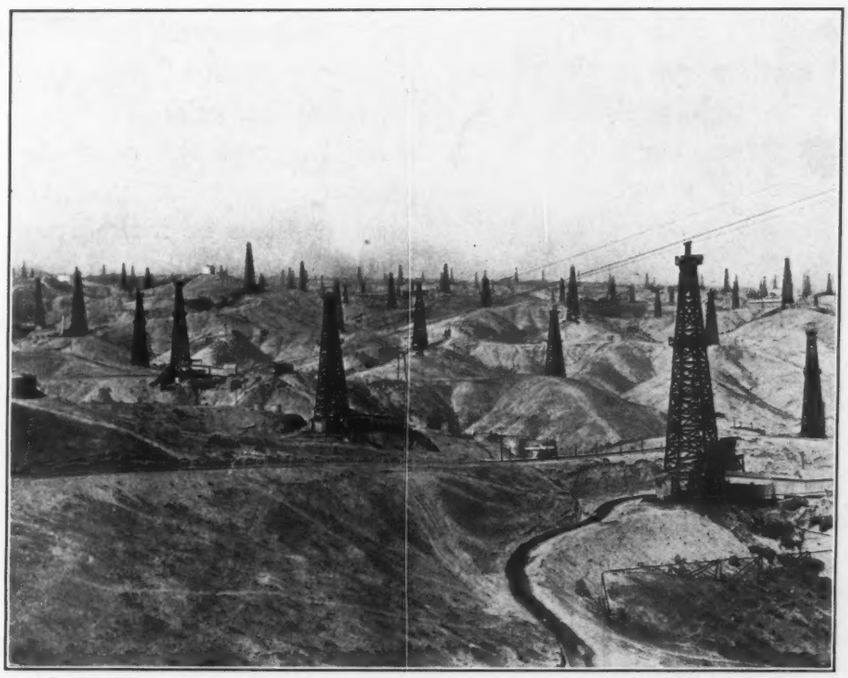
NOVEMBER, 1924



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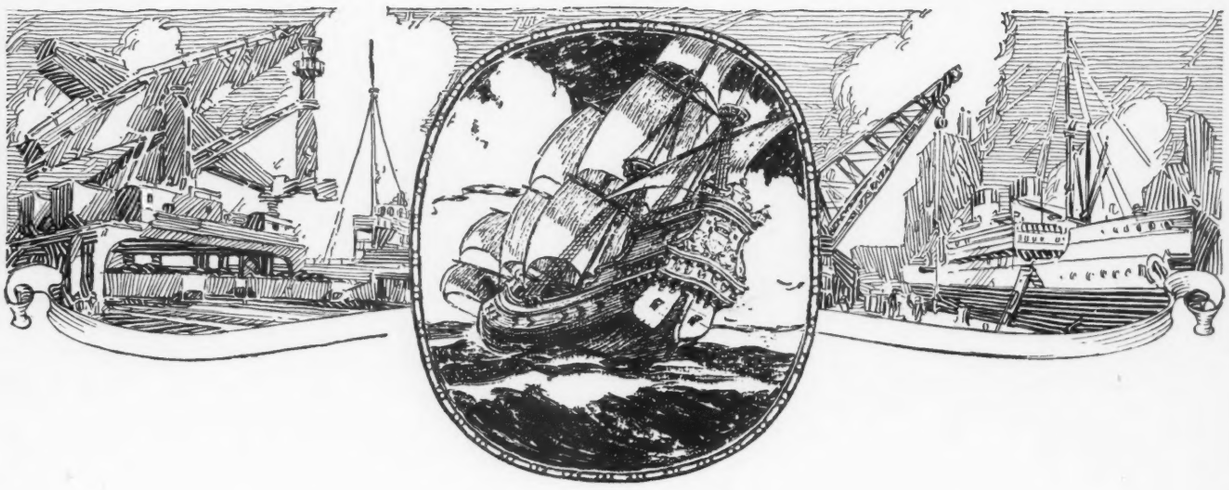
A VIEW OF THE NAVAL OIL RESERVES AT ELK HILL, CALIFORNIA

"Petroleum" (See page 134)

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, CAMBRIDGE, MASSACHUSETTS



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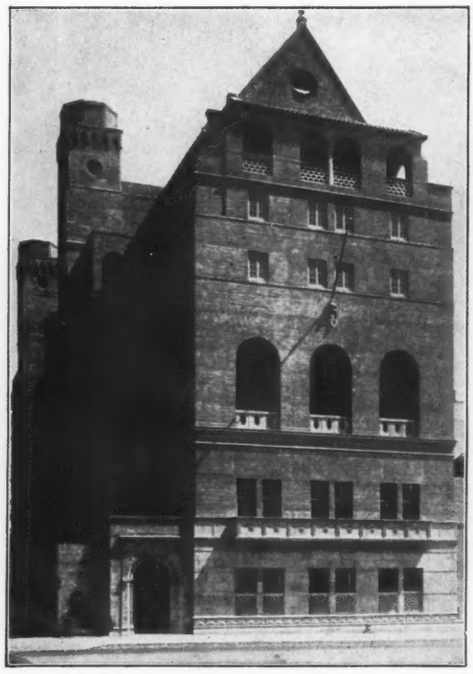

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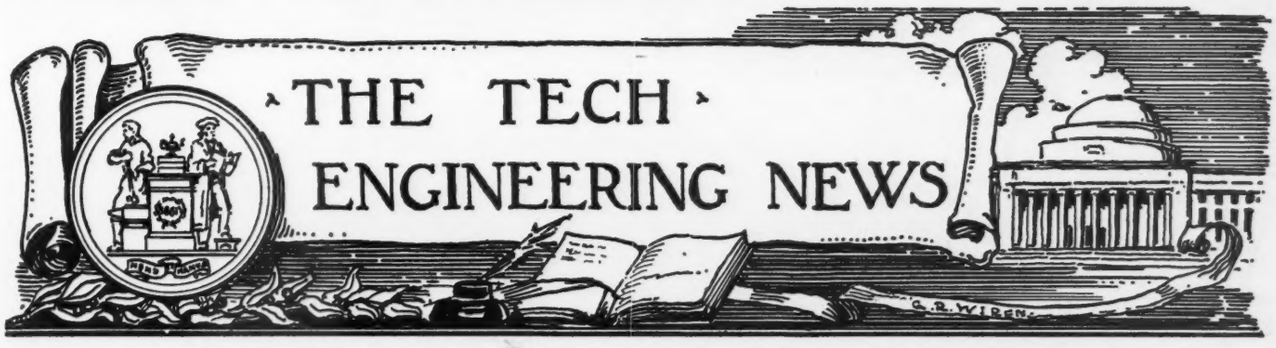

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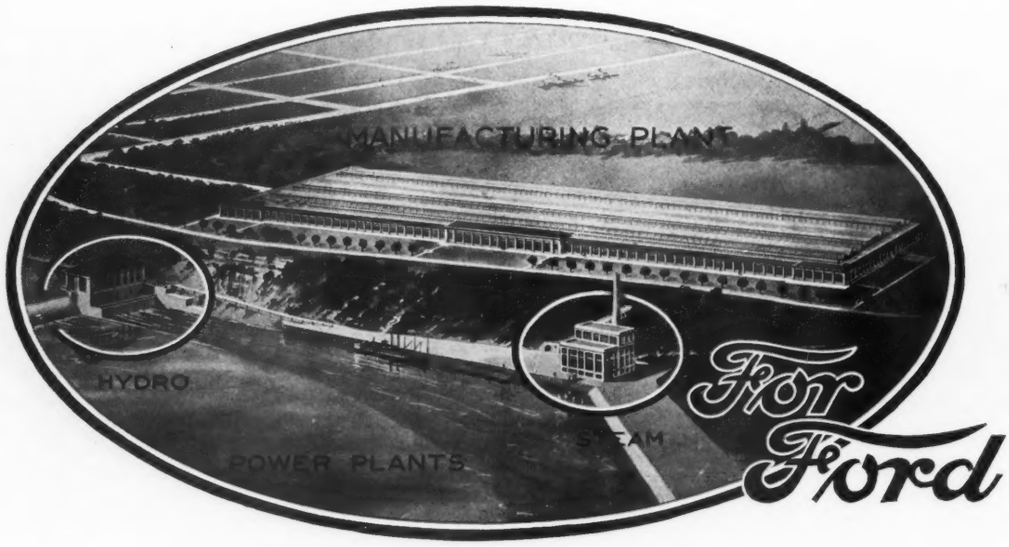

A Complete Industrial Plant for Ford

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THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME V NOVEMBER, 1924 NUMBER 4

ENGINEERING ETHICS IN FINANCE

By GEORGE J. FERTIG

Consulting Engineer, Hornblower and Weeks

ENGINEERING is a valuable profession. For actual application as a profession, however, engineering requires a knowledge of much more than merely exact scientific principles. Just as laws are of limited value without executive assistance and policies for their enforcement, so engineering training for professional application demands an additional means for bringing it into a state of usefulness. Before any branch of endeavor advances to the place where it can be classed as a profession it must have passed through notable stages of development. Besides the gradual accumulation of knowledge peculiar to the field of endeavor on the part of the professional individual, there must likewise be developed a gradual appreciation of the utility and value of such knowledge on the part of the public in general. There must be some understanding between these two parties as to what each may expect of the other, first, as regards the very special conditions determined by any specific enterprise for which the services of the professional might be required and, secondly, as regards a much more intangible and frequently unwritten series of attitudes and behavior upon the part of the professional. It is this second unwritten understanding which invariably falls within the realm of ethical considerations and without which no endeavor can rightly be termed a profession.

Ethics deals with the elements of human nature. It is concerned with a treatment of human action and reaction, considering them not as actual facts but dealing with them with reference to certain standards of truth and propriety. In order that engineering knowledge may be brought from the realm of theory over into the field of public usefulness and advantage it must be conveyed and influenced by ethical forces. The engineer, in his relation to the public as well as in his association with fellow members of his profession, is called upon to recognize definite standards of conduct which he must allow to direct his proceedings.

The engineering profession within the last few years has recognized the importance and virtual necessity of ethical codes and has straightway drawn up standards to govern its members both with regard to their separate branches of engineering as well as to the unified profession in general. Although the major requirements which sound ethics makes of all classes of engineers are essentially the same, certain of the considerations which are requisite from special classes vary. Mechanical engineers find themselves bound to exercise caution for the welfare of their employers and associates in cases which perhaps electrical or chemical engineers do not experience. On the contrary the peculiarities of chemical patents, of electrical requirements or of civil engineering practice may require the corresponding professional men associated with these engineering subdivisions to emphasize additional care and consideration for the public which other members of their engineering family may never have to regard. Just as the chemical, electrical, civil and mechanical professions have ethical considerations to apply, each in a somewhat different manner from the other, so the peculiar ethical status of the engineer in finance is determined by the particular conditions with which he finds himself surrounded.

Finance is the science of money. It is a field of endeavor which deals with rates of interest and of exchange, with the origin and conduction of industrial and commercial enterprises and with the negotiation in securities and investments. Its close intimacy with industry suggests also a necessary connection with engineering enterprises, for engineering and industry are inseparable. For the establishment of a new undertaking or for the expansion of an established business, money is usually essential. Financial concerns are consulted and requested to supply funds for promising projects. Depending upon the results of an investigation of the proposed enterprises, the financial firm agrees to guarantee the obtaining of the necessary capital by arranging for the sale of suitable securities. The undertaking must first be carefully analyzed for soundness in principle, process and practice. The products of manufacture must be of such a nature as to be capable of disposition and of such stability of future demand that the future of the undertaking seems assured, both from the standpoint of the investors who have purchased the securities of the company in question as well as from the viewpoint of the financial house issuing these securities.

The obligations of the professional engineer in finance, then, are clearly divided among four classes of people. His services as a consultant require his best efforts to be in consideration of his employing firm. Secondly, there exists his duty to the investing public whose resources ultimately supply the capital for the industry under his analysis. Thirdly, there is an important obligation due to the firm whose future he attempts to judge, a consideration which is hardly of more weight than that of his fourth responsibility to the organizations and industries which are to utilize the products of manufacture of the company it is his privilege to investigate.

During the performance of his duty for his employing firm in conducting the investigation of particular industrial enterprises, the engineer is conscientiously called upon to make inquiry into all matters which may or may not affect the ultimate success of the undertaking. He must, therefore, be informed frequently of particular technical methods and secret processes of manufacture. He will regard such information always as confidential and refrain from improperly disclosing it. It is essential that his understanding

(Continued on page 158)

PETROLEUM

By LUIS de FLOREZ, '11
Consulting Engineer

THE story of oil is a long one, and it is hardly possible in this article to do more than to lay before you a few facts and generalities relating to the petroleum industry. If we stop to think that in the year 1890 the world's production was 76,000,000 barrels; in 1900, 150,000,000 barrels; in 1910, 326,000,000, and in 1920, 690,000,000 barrels; that it has more than doubled itself in each of the ten-year periods mentioned and, further, that in attaining a figure of 855,000,000 for 1922, it is well on its way to repeat the performance, we will realize the sudden and phenomenal growth of a new industry which supplies the world with another staple product, whose importance is as great as that of steel.

The advent of steel was rapid enough, yet its beginning in the latter part of the last century is becoming clouded in the mists of the past, and steel products are taken for granted as having always existed. There is hardly one of us, however, who cannot remember the time when there were no filling stations, when our warships were fired with coal and when the only prominent exponent of petroleum products was kerosene.

Naturally this would lead to the belief that the discovery of petroleum is a recent one, but this is not the case, for it was recovered in quantities before steel was made. In fact, it was known through antiquity and is mentioned in the oldest of chronicles. We are told that the walls of Babylon were cemented with pitch or bitumen which floated down the River Is, a tributary of the Euphrates, from some up-country seepage.

Petroleum is referred to in the Bible in several instances and in fact one ingenious historical writer has stated his belief that Elijah's rapid rise to heaven in a chariot of fire was due to his careless handling of certain volatile oils obtained from seepages in Palestine and sometimes used for religious rites.

Crude petroleum is not an entity but a mixture of many different hydrocarbon compounds. Crude oils found in different regions vary widely in nature and it is often the case that one field will produce several grades of oil. For instance, Pennsylvania crude is predominantly a high gravity green oil of paraffin base, comparatively free from sulphur and "sweet" smelling, while most California and Mexican oils are low gravity, brown-black in color, of asphaltic base, and of rank odor with high sulphur content. It may be said that practically all kinds of crudes contain hydrocarbons similar in useful properties, although varying in composition and in proportion, and that the classification into paraffin or asphalt base oils does not generally affect the use to which the crude is put, excepting in the case of certain specialized products.

The origin of petroleum has long been a matter for discussion and at best its formation is a matter for conjecture. The most strongly substantiated theories, however, are based on the assumption that petroleum is the result of the decomposition of marine organisms deposited in shallow inland seas along with the materials forming the sedimentary rocks with which petroleum is universally associated. There are, however, strong adherents to the theory that petroleum was formed synthetically by the action of water or steam on mineral compounds in a similar manner to that in which acetylene (C_2H_2), a hydrocarbon gas, is formed by the action of water on calcium carbide.

The natural reservoirs, in which oil accumulated, are porous sandstones and limestone beds overlain by impervious strata and either folded to form anticlines and domes or cut off by faults or lensing. As may be expected, gas is usually found in the highest part of the reservoir, oil next, floating on saline or mineral water, which usually occupies the structural valleys, or synclines. When water is not present in the porous bed, oil accumulation sometimes occurs independently of structure. The illustrations are sections of ideal structures, innumerable variations and combinations of which are actually found.

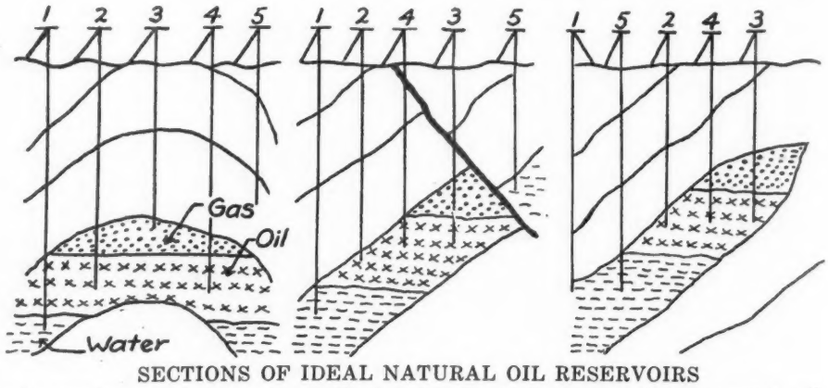
The geology of oil fields is a broad subject and has constituted the life study of many brilliant men and we will have to content ourselves at this juncture to merely indicate its scope and point to the remarkably accurate predictions which can be made at the present time concerning oil deposits, with the aid of available data constantly being collected.

Oil at present is obtained from practically all parts of the world. The oldest fields existing are in Russia, Roumania and the United States. The Russian fields are chiefly located in the region of the Apsheron Peninsula and Baku, and the Roumanian fields in Transylvania and the Galician fields in Austro-Hungary. Oil is also found in the East: in India, Burma, Persia, in Borneo and in China.

The United States fields have been generally divided into the Eastern or Appalachian fields, which include the Pennsylvania deposits, those of Ohio and Indiana; the Midcontinent field, which includes the deposits of Oklahoma, Kansas, North and Central Texas, Louisiana, etc.; the Rocky Mountain field just west of the Rocky Mountains; the Gulf Coast field, which, as the name implies, is adjacent to the Gulf of Mexico; and California fields on the West Coast.

The oil-producing region of Mexico lies along the coast between Tampico and a few miles south of Vera Cruz. There are two general divisions of this area, namely, the Panuco field which lies in the north along the Panuco River and in which may be included the Ebano field; and the so-called South fields which range from Dos Bocas to Tuxpan and include such sections as Cerro Azul, Tierra Amarilla and Potrero del Llano.

There is considerable oil to be found in South America but the only fields



SECTIONS OF IDEAL NATURAL OIL RESERVOIRS

As may be expected, gas is usually found in the highest part of the reservoir, oil next, floating on saline or mineral water, which usually occupies the structural valleys or synclines.

that are at present producing any quantity are those in Venezuela which are located in and about the Gulf of Maracaibo. Production is being obtained and exploited at the present time in the Argentine and the Government of that country is now building a refinery to take care of its own needs. Rich sands are known to exist in Colombia and doubtless when the time comes, the region will produce in great quantities.

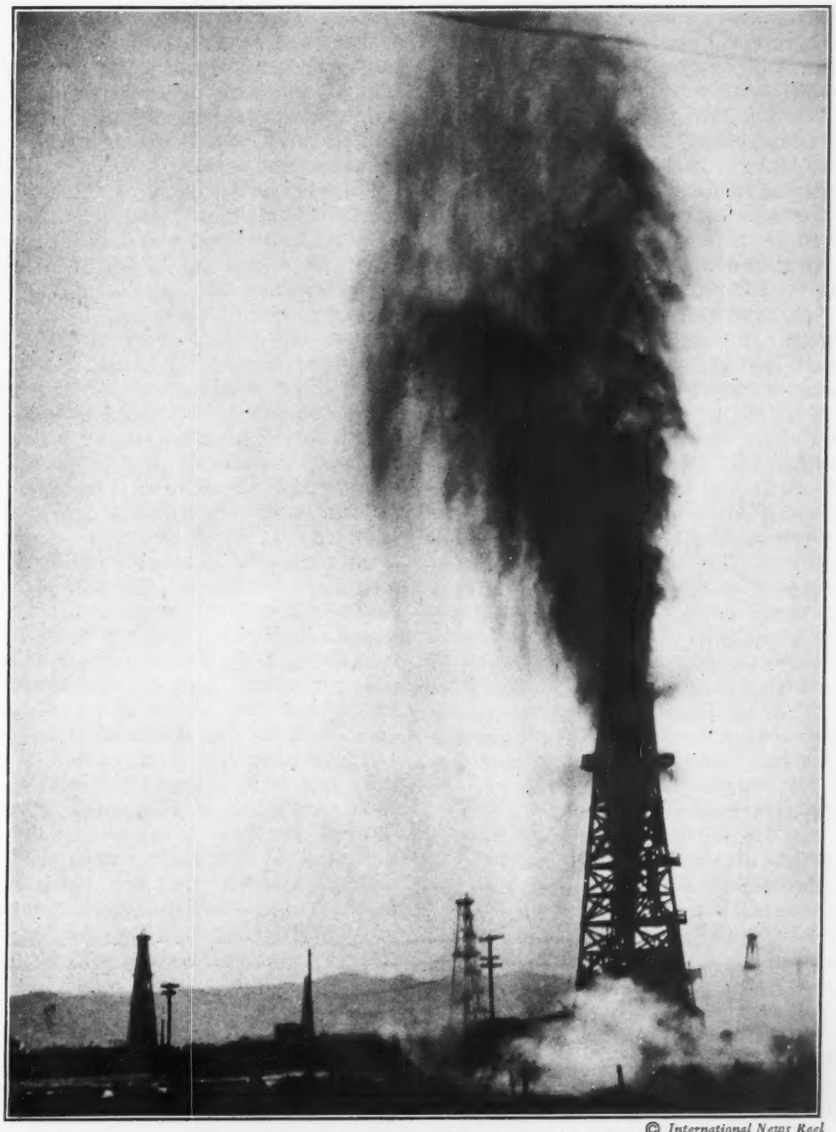
Petroleum was first obtained from natural seepages in many localities and when it was found to be useful for other than medicinal purposes, some attempt was made to recover it by digging crude wells.

In Russia the earliest wells were dug by hand, the usual procedure being to dig a pit six or eight feet square in section provided with boarded sides to prevent collapse, and with staging at regular intervals used to pass up the earth to the surface of the ground. The uncomfortable position of the bottom man in the well can be readily imagined, for he had to make a quick exit should oil or water be struck. I believe it was customary to sound a few feet ahead with an iron bar to give indication of such an occurrence, nevertheless there were doubtless many casualties. Wells of 150 to 400 feet were dug by this method.

There is an amusing incident that is told around the oil fields, dating back to the days of drilling for brine and describing how oil was found in Kentucky, although not duly appreciated. It appears that an enterprising contractor undertook to find water on a site with apparently little success, and that, being a Kentuckian, and there being in those days no law against liquid consolation in case of adversity, he was not easily discouraged and said that he would drill till he struck water or hell. Shortly after, he struck oil under considerable pressure which blew over the top of the derrick and fired. History tells us that, having realized he had reached one of his objectives, he started up wind at a remarkable speed and there is no record of his ever having stopped.

Present day drilling is accomplished in general by two different methods: the standard, or cable-tool method, and the rotary method. A combination of the two is in common use in California. A third method, that of diamond-core drilling, is now in practical use and may be the method of the future.

The first consists of boring a hole by the impact of a heavy piece of steel or string of tools suspended from the end of a cable and which is given a vertical reciprocating motion by a suitable mechanism. To accomplish this a steel or wooden derrick of 70 or 80 feet in height is erected over the spot where the well is to be drilled. A steam engine and boiler are placed about 30 feet from the derrick floor and drive a large wooden wheel known as a "band wheel" which is placed between the derrick and the engine. The band wheel imparts a reciprocating motion to a large horizontal beam with a pivot in the center, known as a walking beam, one end of which comes directly over the drill hole. On the opposite side of the derrick is erected a wheeled drum, known as the "bull wheel." One end of the drilling cable is passed over a pulley in the crown block of the derrick and made fast to the bull wheel and the cable is then reeled up on the bull wheel, which serves as a hoisting drum to raise or lower the tools. To the other end of the cable are attached the drilling tools, consisting, in order, of a rope socket, jars, stem and bit, the whole being 50 feet or more in length.



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OIL WELL MAKES DEBUT AS A GASSER

Water, stones and mud were hurled 150 feet into the air at a pressure estimated at 2,000 pounds per square inch.

Rotary drilling, generally speaking, consists of boring a hole in the ground by rotating a steel craft provided with a suitable bit for cutting soil and removing the borings by pumping a fluid through the hollow drill shaft in such manner that the borings will be floated out of the hole. This method of drilling also requires the use of a derrick, which in this case is somewhat higher in proportion, attaining the height of 130 feet.

The rotary table itself consists of a flat disc rotating horizontally and being driven by a suitable gear mech-

anism at its edge. It is pierced in the center by a hole through which the drill pipe passes and which is provided with suitable bushings which permit a free vertical motion to the drill pipe but force it to turn with the table. The drill pipe is partly suspended from the top of the derrick and provided at its upper end with a hollow swivel joint through which the flushing liquid is pumped to the bit rotating in the hole.

Oil is found at varying depths, some wells being as shallow as 400 or 500 feet, and others reaching a depth of over 6,000 feet, the deepest well on record being the Lake well, Harrison County, West Virginia, reaching a depth of 7,579 feet (unproductive). Wells in California are producing oil from a depth of over one mile.

Where drilling is done in gusher country, such as in Mexico and some parts of the United States, great care is taken not to drill through the cap rock without preparing for an emergency. Of course, the initial wells in any unknown country sometimes result in total loss, due to the excessive pressure under which the oil flows and the fact that a well flowing wild will often catch fire before it can be brought under control.

In Mexico it is customary to drill within a safe distance of the oil sand and then fit a large gate valve on the casing and drill through this. After oil has been struck and the tools removed or blown from the casing, this gate valve is gradually closed and the well is then said to be capped and connection can be made with the pipe line or storage. Sometimes, it is necessary to run it at a reduced rate in order to avoid the accumulation of excessive pressure. It is also necessary to anchor the casing to the surface of the ground by a large cap of concrete so that the pressure will not blow the casing out of the ground.

Of the many wells lost in new fields, perhaps the most surprising case was that of the Dos Bocas, south of the Panuco River in Mexico. Oil was struck under a pressure of some 1,200 to 1,400 pounds per square inch and not only blew the tools and the rig away from the hole but the force of the gas and oil rising carried away the earth for several hundred yards around the hole and blew the casing clear out of the ground. The jet of oil and gas caught fire from some of the adjoining boilers and burned for 58 days, making a flame approximately a mile in height which illuminated the countryside to the extent of enabling one to read plainly at a distance of from 10 to 12 miles from the well, at night. Several million barrels of oil were lost in this well and all that remains today is an enormous crater about one-half mile across, from which large quantities of salt water flow and through which gas arises occasionally. It is difficult to imagine a conflagration of this size and the energy pent up within the earth.

Experienced drillers watch very carefully the indications in a new country and it is probable that as time goes on the possibility of losing a well such as the Dos Bocas is becoming more and more remote.

After a well has been drilled, it does not necessarily flow its full amount and often has to be shot with nitroglycerine to bring it into full production. The shooting of a well consists of lowering into the hole a charge of nitroglycerine, usually in tin cans, and then detonating this by electricity or by dropping a weight to detonate it. The explosion which occurs at the base of the well opens fissures in the productive horizon and permits the oil to flow more freely toward the well. There are cases, of course, where shooting has brought in not only oil but water, which causes great difficulty and has to be excluded.

After it has come from the ground, the crude oil is accumulated in reservoirs or tanks awaiting shipment. Storage facilities in the early days consisted of earthen reservoirs or wooden tanks but these are being replaced by steel tanks of capacities up to 80,000 barrels, and in some cases by concrete reservoirs of even larger capacity. The larger the unit, of course, the more economical it is since the cost of the shell of a tank of usual dimensions increases roughly as a square function, while its content increases as the cube, so that obviously less material is required for a unit of volume as the general dimensions increase. The 55,000-barrel-tank of 114-foot diameter and 30-foot height is perhaps the most generally used today, though it is rapidly being superseded by those of 64,000 and 80,000 barrel capacity. It is customary to erect a large number of tanks within 300 or 400 feet of each other, in regular rows with dikes or levees separating them, to form a tank farm. Tank storage at the oil field is usually only temporary in character to hold the oil until pipe lines can be laid.

Oil has to be pumped to permanent storage and to refineries by means of pipe lines. This country has today over sixty thousand miles of pipe lines which are common carriers operated under regulations similar to the railroads, which not only permit the transfer of the crude oil to storage points, but enable us to ship it hundreds of miles to our refineries situated near our markets.

In the Panuco district, Mexico, oil is barged down the River Panuco by means of shallow draft barges towed by stern-wheelers and brought a distance of about 54 miles to the harbor of Tampico where, it is discharged into shore tanks to await loading in sea-

OIL TANK CARS AWAITING THEIR TURN TO BE FILLED AT THE REFINERY

This kind of oil transportation is an expensive one, and when possible is supplanted by the less costly method of water transportation.

going ships. The Panuco fields are only about 34 miles from the seacoast as the crow flies, but the winding course of the river makes it necessary to travel nearly double that distance to reach the coast. Tampico itself has a fairly good harbor but there is a shallow bar at the entrance of the river which sometimes makes it necessary for the steamers to partly fill at the wharf and then finish loading outside the bar from a barge.

The building of pipe lines has been somewhat discouraged owing to the unstable conditions of Mexican politics and the large investment required for the construction of a suitable line, particularly since the oil is very heavy and has to be pumped hot. It has been considered preferable, whenever possible, to handle it with barges, which could always be towed out and put into service elsewhere if the conditions required, although there are, of course, some pipe lines in the district.

The loading problem in the Venezuelan fields is a difficult one since most of the oil is found within a short distance of the shores of Lake Maracaibo, which has only a very shallow connection with the Atlantic Ocean. It is not possible for steamers of over 10- to 12-foot draft to cross the bar at the mouth of the lake, as it is called, and the moving of the oil can be accomplished only with barges, which take it to Curacao, where it is transferred to ocean-going steamers. It is interesting to note that during the past three or four years, producers in this section have remodeled a number of British monitors that were used during the war to bombard the coast of Belgium, and, having fitted them with tanks, they are now using them to ply back and forth between Maracaibo and Curacao. These ships were especially fitted to maneuver in shallow waters and although they are somewhat expensive to run, have served a very useful purpose.

We have seen in the foregoing, a brief picture of petroleum as it occurs in the ground and as it is brought to the surface, and how it is transported to refineries. We cannot help noting the effect of transportation which is of vital importance in the oil industry since it sometimes costs more to transport oil than to purchase it at the well. In other words, oil itself is not valuable until it can be put to use, and consequently the finding of petroleum in some remote corner of the earth is only of potential value until it can be moved from this point and brought to the market.

This is illustrated by the fact that a few years ago, when ocean freights were high, Panuco crude oil could be purchased for 14c a barrel at the well; it then cost about an equal amount to bring it from the well down the river to the terminal at Tampico. From there, there was about a 10c handling charge to load it on steamers, and a Government tax of about 7c, making a total of about 45c. The oil was then transported to New England for about 60c or 80c a barrel, so that the oil upon receipt cost about $1.05 to $1.25 per barrel. In other words, the actual cost of the oil at the well was from 10 to 15 per cent of its value when it reached its destination.

These facts have largely influenced the location of refineries and it is found to be almost invariably more economical to develop them in close proximity to a market. In this manner, all the products from crude oil can be transported in bulk in the same carrier, whether ship or pipe line, and they can then be separated according to the local requirements after arrival.

The refining of crude oil to produce petroleum products with which we are all familiar, is primarily a process of extraction or separation by distillation. That is to say, the crude itself is a mixture of hydrocarbon compounds of varying physical properties from the most volatile fractions, such as gasoline, to solids like wax and asphalt. When it is subjected to heat in suitable apparatus, its various components may be successively vaporized; thus it is possible to recover them by simply segregating the condensate between certain boiling ranges, the last fractions being left in the apparatus as a residuum.

When a still is charged with crude and heat applied to it, the more volatile products will be the first to vaporize, as may be expected, and as the distillation progresses, we will obtain compounds of increasingly high boiling points. It is a fact that the more volatile compounds are of less density than those of higher boiling points and therefore the term "lighter" has been generally applied to describe the compounds of lower boiling ranges. Thus we would class gasoline as a light distillate and a lubricating cut as a heavy distillate. A residuum would probably be called a heavy oil rather than one of high boiling point.

Different types of oil are mainly classed in accordance with their specific gravity, boiling range and viscosity or degree of fluidity. There are, of course, many other characteristics which are defined in specifications, such as color, sulphur content, sweetness, flash point, fire point, etc., which we will not go into owing to the limited space available.

The term "boiling range" speaks for itself and means the range of temperature at which the various components of the distillate will vaporize. Incidentally, the terms "flash point" and "fire point" are in a measure indicative of the degree of volatility, and when it is said that an oil has a flash

(*Continued on page 149*)

OIL TANKERS DOCKED AND READY TO DISCHARGE THEIR LIQUID CARGO

This method of transporting oil is fast surpassing that of transportation by rail because of the great savings which are possible with its use.

AERIAL PHOTOGRAPHIC MAPS

By GERARD H. MATTHES, '95
Consulting Engineer, New York City

WITHIN the past four years the application of aerial photography to map making has gained steadily in favor with engineers. The progress that has been made in this new art, and I should add new science, has been very rapid, and there is every indication that its further development will bring about entirely new aspects in that branch of engineering that is devoted to surveying and mapping. Indeed, in some respects, material changes have already been wrought in it.

There is no better way of approaching the subject than by reviewing briefly the principal uses to which aerial photographic mapping has been put up to the present time, as follows:

1. *For locating high-tension power transmission lines.* This is the most popular form of aerial map, and has by this time been used by about 25 electric power companies in various parts of the United States and Canada. Some of these companies are definitely committed to its use in preference to ground surveys by the preliminary transit line method. The principal advantages are: (*a*) ability to map extensive areas without arousing the suspicion of land owners to the effect that a right-of-way is being sought by a corporation. This implies material reductions in right-of-way costs; (*b*) more information is made available for the money expended than is procurable by any ground survey methods; (*c*) better alignment of the power transmission line is made possible, because of ability to view all obstacles to line construction, resulting in fewer angles and less interference with private interests; (*d*) material savings in time may be effected in locating the line and also in constructing it, because the map shows all transportation routes down to the smaller footpaths, thus facilitating the delivery of materials along the entire route. The scale commonly used in such aerial maps is 800 feet to one inch.

2. *Reservoir Surveys* for water power and domestic supply. Especially where a contour map is desired, and contours can be located on the photographs direct by plane table survey, is this method to be recommended. The Alabama Power Company, under the direction of O. G. Thurlow, '04, Chief Engineer, mapped last year about 500 square miles of Tallapoosa River valley, scale 800 feet to one inch, and used the maps before the Federal Power Commission in making application for permits for several water power developments. This company is one of the few that has acquired complete equipment for making such aerial surveys with its own personnel. A yet more extensive water power survey executed by this method is that of the War Department on the Tennessee River and tributaries, in the course of which over 2,000 square miles were mapped on a scale of 1,250 feet to one inch. In Minnesota similar surveys are being made on 1,000 feet to one inch.

3. *Harbor Surveys.* Where large bodies of water are involved, land surveying presents many difficulties, and aerial photographic surveying is unquestionably the quickest and most accurate method. It brings out not only the exact outlines of fixed objects such as docks, wharves, channels, piers and islands, but shows the sizes and shapes of the movable objects in the form of boats and barges that frequent such waters, and thereby simplifies the working out of problems relating to necessary clearance, width of channels and length of docks required. Mobile, New Orleans and Boston harbors are among the principal ports mapped to date.

4. *City Maps.* A number of the larger cities in the United States have been mapped from the air, but in some cases the scale used was too small to render the map of maximum value. Kansas City, Newark and New York City are instances of maps on 600-foot scales that permit of their being used for city planning, zoning and even regional planning. The map of New York City was completed about a month ago after about a year's work in its production. Besides the city proper on 600-foot scale, the entire 625 square miles of Greater New York were mapped at 2,000 feet to one inch. This map is now being used by the Board of Estimate and Apportionment in planning improvements, extensions and for a variety of other purposes having to do with modern city administration problems.

5. *Traffic Studies.* Closely related to the last mentioned use are aerial maps for studying automobile traffic in congested areas. The best map of this kind was that made for the Automobile Club of Southern California of the heart of Los Angeles, a city that is suffering from congested traffic conditions in the worst possible form. This map covered only 6½ square miles but was made at 200 feet to one

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RURAL DISTRICT SHOWING FARM LANDS AND WOOD LOTS, ORCHARDS AND COUNTRY ESTATES

The scale is 800 feet to one inch. Photographs of this scale are comparatively inexpensive to make and are therefore used where minuteness of detail is not of primary consideration.

inch, or large enough to permit of seeing automobiles and pedestrians with great clarity. It has been used extensively in planning street widenings and other forms of traffic relief.

6. *Flood Control.* The Colorado River delta, covering some 325 square miles of waste land, subject to shifting channel conditions and overflow by floods was mapped from the air for the purpose of planning levees for the protection of the irrigated lands in the Imperial Valley near by. This map is at 1,000 feet to one inch and affords a fine example of the value of aerial surveys in a region where ordinary surveying cannot be carried on except at great expense and hardship.

7. *Timber Surveys.* In Canada extensive aerial surveys have been in progress for the past three years covering large timber holdings controlled by pulp wood interests. The methods employed have completely superseded the old-time timber cruising system for estimating the stumpage value of a forest. It has been found to be more accurate and to require only a fraction of the time formerly needed. It enables timber experts to recognize the species and estimate the ages and sizes of the trees directly from the photographs. Many thousands of square miles of forest land have thus been mapped and their merchantable value computed. Also, the aerial pictures have been found of assistance in planning logging railroads, sawmill and camp locations.

8. *Parks and Landscape Gardening.* There is no better way of laying out parks and playgrounds than by means of photographic maps. It is necessary in this work to take account of all that relates to existing trees, shrubbery, rock outcrops, ravines and water courses, and it is these very features that are brought out in detail in the pictures. Aerial surveys of this kind have been made of Golden Gate Park, San Francisco, covering four square miles at 400 feet to one inch; of Griffith Park, near Hollywood, Cal., on 200 feet to one inch; in Union County, N. J., a 10-square-mile area at 400 feet to one inch; and a small area for the Westchester Park Commission, New York, at 200 feet to one inch.

9. *Legal Evidence.* Aerial maps have been used in law suits as evidence in a number of cases, a notable instance being that of General Petroleum Co. *vs.* Bethlehem Steel Corporation in connection with objections raised to the extension of a dry dock in Wilmington harbor, California.

10. *U. S. Geological Survey Quadrangles.* During the past year considerable progress has been made at the U. S. Geological Survey, Topographic Branch, with aerial map construction. A satisfactory system has been evolved in which the aerial photographic work is performed by members of the Army Air Service, and the locating of contours is done by Geological Survey topographers on skeleton maps prepared by pantographing roads, streams, buildings, etc., from the pictures onto plane table sheets. It has been found that the work is greatly expedited and the cost reduced nearly one-half.

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UNIMPROVED LAND WITH CULTIVATED FIELD ALONGSIDE

The scale is 300 feet to one inch and serves very well to show up the timber and the partly waste land. Even the cattle trails can be seen converging to the watering place at the river bank.

11. *War Department maps.* At McCook Field, Dayton, Ohio, the War Department maintains an experimental and research laboratory for aerial mapping in charge of officers of the Corps of Engineers, which has been turning out very excellent work. The objective is to produce maps of large areas of enemy territory in times of war in the least possible time, yet sufficiently accurate to serve as artillery maps. The camera devised for this work possesses four lenses all of which are exposed simultaneously. At an altitude of 15,000 feet above the ground a scope of country 9 miles in width is photographed at each exposure.

12. *Dominion Land Surveys.* Photography has been used extensively in the Canadian Government surveys. This had its inception in the nineties when E. Deville, Surveyor General, introduced photographic surveying with instruments mounted on tripods. In mountainous regions excellent reconnaissance maps were thus produced. Since 1920 a great deal has been done with aerial photographs, both of the vertical and oblique types. The latter are taken at such an angle as to include the horizon. This, in flat country, makes it possible to construct fairly accurate outline maps without contours at very low cost. Many thousands of square miles have been mapped by this process which has proved itself singularly well adapted to the flat Canadian wilds with their innumerable lakes and impenetrable muskeg swamps.

13. *Railroad Surveys.* A railroad location survey was carried out with the aid of aerial photography between Mexicali and La Bomba for the Mexican government over a year ago. At present an aerial survey for locating 250 miles of railroad in northern Canada is nearing completion. In certain large cities in this country, railroad yards and terminals have been mapped from the air in great detail for the use of the right-of-way and legal departments of railroad companies.

14. *Tax Maps.* A promising field is predicted for the production of tax assessors' maps from aerial photographs. The first map of this kind has been made in Connecticut and has

given much satisfaction. The short time required for its completion as compared with ordinary surveying processes, *i.e.*, a few months instead of several years, and a reduction in cost to one-eighth that ordinarily estimated, are factors that amply speak for themselves. Besides, the photographic map gives information for tax assessing purposes that is invaluable and that cannot be procured by any other method.

15. *European Photographic Surveys.* In Europe a great deal of attention has been paid to theory, and comparatively little to the practical application of aerial photography to map making. Some remarkable work has been done, especially in devising optical processes by means of which contours can be produced from the photographs direct. There are a number of patents covering these endeavors, and a few extensive surveys have been made with their aid. Their introduction into the United States has not been successful thus far, mainly because of the exceedingly elaborate and costly apparatus required, and also because of the excessively large amount of ground control that is necessary to insure the correct operation of the apparatus. Until these patented processes have become greatly simplified it is not likely that they will meet with much favor in this country.

Many other uses have been found for aerial photographic maps other than those here enumerated, but space will not permit of entering into a discussion thereof. Progress maps on construction work, land sub-division of large estates, irrigation projects, highway planning and oil well property surveys, are some of the many uses that come to mind. Their number is being added to almost from week to week.

Scale of Map. The selection of the proper scale is of paramount importance, first, in order that the map may serve the purposes for which it is intended, and, second, because the scale, more than any other element, affects the cost of making the map. A large-scale map, that is, one showing images of objects big enough to be seen in great detail, is costly to produce, calling as it does for taking a very large number of photographs and involving much labor, besides adding to the technical difficulties of assembling the map. Small-scale maps require fewer pictures, and lessen the difficulties referred to. Small-scale pictures, if sharp and clear, will stand considerable enlargement and within reasonable limits such enlargement is no bar to bringing out the desired amount of detail.

The contact prints, that is, photographs printed directly from the negatives, measure 7 inches by 9⅛ inches, which, at a scale of 800 feet, for instance, corresponds to 1.06 miles by 1.38 miles, or an overall area of 1.5 square miles to each print.

Overlap. The customary way is to make the exposures overlapping on each other, by flying the airplane methodically back and forth in straight parallel lines forming so-called strips, and continuing this process until the required area is covered. The camera is turned so that the 9-inch dimension of the pictures forms the width of the strip. Experience has taught the wisdom of allowing generous overlap between exposures, throughout. This is accomplished by having consecutive exposures within strips lap over on each other by about 60 per cent, and lapping successive strips on each other by about 50 per cent. The former is spoken of as endlap, and the latter as sidelap. Theoretically, the net effective area of each exposure will thus be 0.20 of the area of one exposure. This corresponds to 0.29 square mile at a scale of 800 feet to one inch. Stating it in another way, each object on the ground theoretically would be photographed five times. In actual practice this is not always realized because of the difficulty experienced in flying an airplane in perfectly straight lines, and maintaining perfect parallelism between successive strips. Photographing each object five times may at first seem a waste of time and money. The importance of securing ample overlap, however, will become apparent from the following considerations:

(*a*) The central portion of a vertical photograph shows objects in practically vertical projection. Near the edges elevated objects become displaced, due to obliquity of the rays entering the lens, and in case of slight tilting of the camera the edges become subject to distortion more than the center. Therefore, on general principles, the central portion of each exposure is the only area that can be used with safety in delineating the map, and the edges ultimately have to be discarded.

(*b*) In order that a large number of photographs, each covering a compara-

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COUNTRY VILLAGE AND FARMS SHOWING CROPS BEING HARVESTED

The scale is 300 feet to one inch. Photographs of this scale are costly to produce, and therefore are usually made at a scale of 800 feet to one inch and then enlarged to the size desired.

tively small ground area, may be assembled into a consistent map, to a uniform scale and free from distortion, certain geometrical principles must govern, and to make this possible the first requirement is that the center point of any one exposure shall be visible in the exposures to each side of it. Hence the necessity of securing 60 per cent overlap in the direction of flight.

(*c*) For viewing aerial photographs stereoscopically, a certain amount of overlap is a prime requisite. In order that any portion of an area photographed may be capable of being studied in the stereoscope, the overlap must be not less than 50 per cent between any two successive exposures.

(*d*) Ample overlap makes possible the elimination of occasional defective exposures caused by excessive tilting of the camera, small clouds, cloud shadows, or other imperfections.

(*e*) The side lap is primarily needed in order to insure continuity between adjacent strips and affords a safety margin for such irregularities in flight direction and alignment as are bound to occur when flying at high altitudes.

(*f*) An incidental benefit that arises from having both end and side lap, which should not be underestimated, is the ability afforded of viewing obscure objects from more than one angle, and this is especially valuable when using the stereoscope.

Ground Control. The character of ground control that is required for aerial surveys should be gauged according to the importance to be attached to accuracy. As a rule no elaborate system is required. A triangulation net affords the best control but is often costly and moreover calls for specially trained personnel. For most aerial surveys accurately run transit traverses are sufficient. The advantages of the traverse method are that in most cases it confines ground surveying operations to roads and trails, involving a minimum of brush cutting, and the work can be done by any competent surveyor. Sometimes it is desirable to mark the more important control points by means of white cloth or dry powdered lime in the shape of circles and crosses large enough to show plainly in the photographs. More often natural objects are selected as control points, such as lone trees, fence corners, road intersections and the like, and no marking need be resorted to.

Camera. The standard cameras used in the United States are of special construction and are made with lenses of 8-inch, 10-inch, 12-inch and 20-inch focal lengths. The film is 9¼ inches wide and 75 feet long, capable of taking over one hundred exposures 7 by 9 inches. In the Eastman camera the film is sucked by partial vacuum against the back of the film holder, and in the Fairchild camera the film is pressed flat against a glass plate at the instant of exposure to prevent bulging or warping of the film. In the Bagley camera the film is gripped in a frame which accomplishes the same object. The lenses are so ground as to produce images practically free from distortion. A gimbal joint support and spirit level make it possible to maintain accurate vertical position of the camera.

Stereoscope. This instrument, which has been referred to again and again in this paper, is an indispensable adjunct to the efficient use of aerial photographs. It is usually built without lenses, depending upon two successive reflections from mirror surfaces to bring the images of two photographs in juxtaposition. In other respects it is similar in principle to the old-time parlor stereoscope which of late has become popular in the school room. In viewing aerial pictures it is necessary to take the photographs, two at a time, and to make sure that portions of each cover the same ground area. It is the latter area that will appear in relief, and when properly adjusted to suit the eyes of the observer, the topography of the country is seen with astonishing clarity. Hills, mountains, forest trees, houses, and even such minor features as stone fences and small trees stand out as though endowed with a third dimen-

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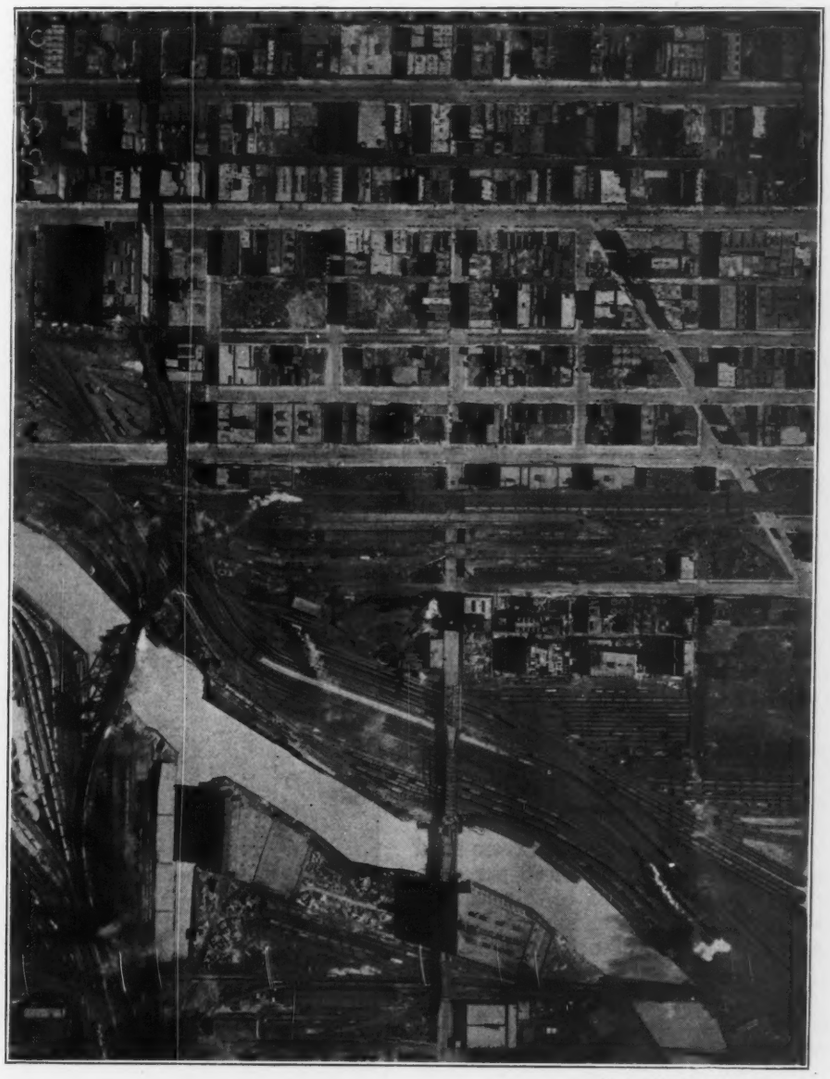

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VERTICAL VIEW OF A CITY AREA

The scale is 400 feet to one inch. There are shown in the photograph grain elevators, business blocks, railroad yards with complicated track crossings and a waterway spanned by bridges.

CLEAR FUSED QUARTZ MADE IN THE ELECTRIC FURNACE

By EDWARD R. BERRY

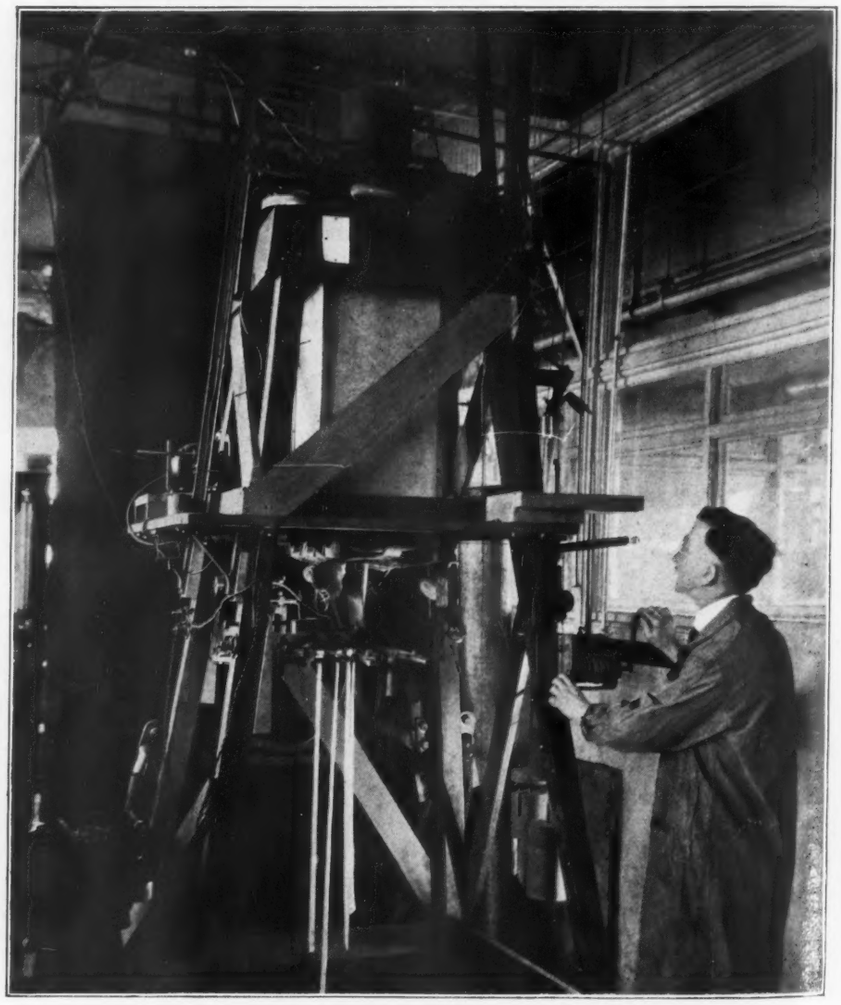
Thomson Research Laboratory, General Electric Company

IT is the purpose of this article to present some of the recent results of the development of clear fused quartz and to focus attention on some of the surprising properties of this material. The art of making fused quartz dates back to 1839 when Gaudin, in France, discovered the general thermal properties of fused quartz. A number of advances have been made in the art since that date by various investigators; but most of this work has been concerned with the opaque variety of fused quartz usually made from sand. It is only during the past twenty-three years that the development of clear fused quartz has made very rapid progress.

It has been possible for many years to make fused quartz of a high quality in small sections and lengths by hand labor in the ordinary blast flame, using gas and oxygen. This has been done by piecing together small sections of crystal in the flame; or by adding silica powder from time to time until the piece has grown to the heating limit of the flame, an obviously slow and expensive process. From this step in the development of the art to the point where very large masses of equal quality can be made has been a long and difficult one. In the last few years the advances made by the process described in this article have been so rapid and far-reaching that there seems to be no limit now to the size of high-quality clear fused quartz which can be made, except that which may be imposed by mechanical difficulties.

When it is desired to obtain fused quartz of the quality which is illustrated in this article, it is necessary to start with the very highest quality of raw material, of which there is none better than water clear crystals. It is much more difficult to make fused quartz of this high quality from sand even if its purity exceed 99 per cent. The rock crystal used in this work is water clear and contains probably less than two-tenths of one per cent impurities. The surfaces are often encrusted with iron oxide and other foreign material and the crystal itself can be seen to contain clusters of small bubbles. The crystal is therefore washed in acids, and then broken up and the unsuitable pieces discarded.

There are two distinct steps in the preparation of tubes, rods, ribbons and cane; the most important of which is the initial fusion. The clean quartz crystals, which are of various sizes, are packed as densely as possible in a graphite or carbon crucible so that during the cracking of the crystals, which is bound to occur as the temperature is raised, the parts cannot separate and allow any small amount of gas which may be present to enter the many crevices and thus form bubbles. Those tightly packed crucibles are placed in a modified vacuum furnace and the temperature raised as quickly as possible to the melting point. During this fusion the pressure in the furnace is kept as low as possible. The time required for fusion will vary with the conditions and in all cases no more than 45 minutes is necessary. The energy rate of fusion is from 3 to 8 kilowatt-hours per pound of quartz, and the loss of quartz due to volatilization is negligible compared with other charges. The result of this first fusion is a clear, transparent slug containing comparatively few bubbles ranging in size from a pin point to 2 or 3 mm. in diameter. Whether these bubbles have been formed by a gas or by silica vapor, it must be remembered that they have been formed at a temperature of about 1800 deg. C.; and consequently their pressure at room temperature is very



APPARATUS FOR MANUFACTURING CLEAR FUSED QUARTZ

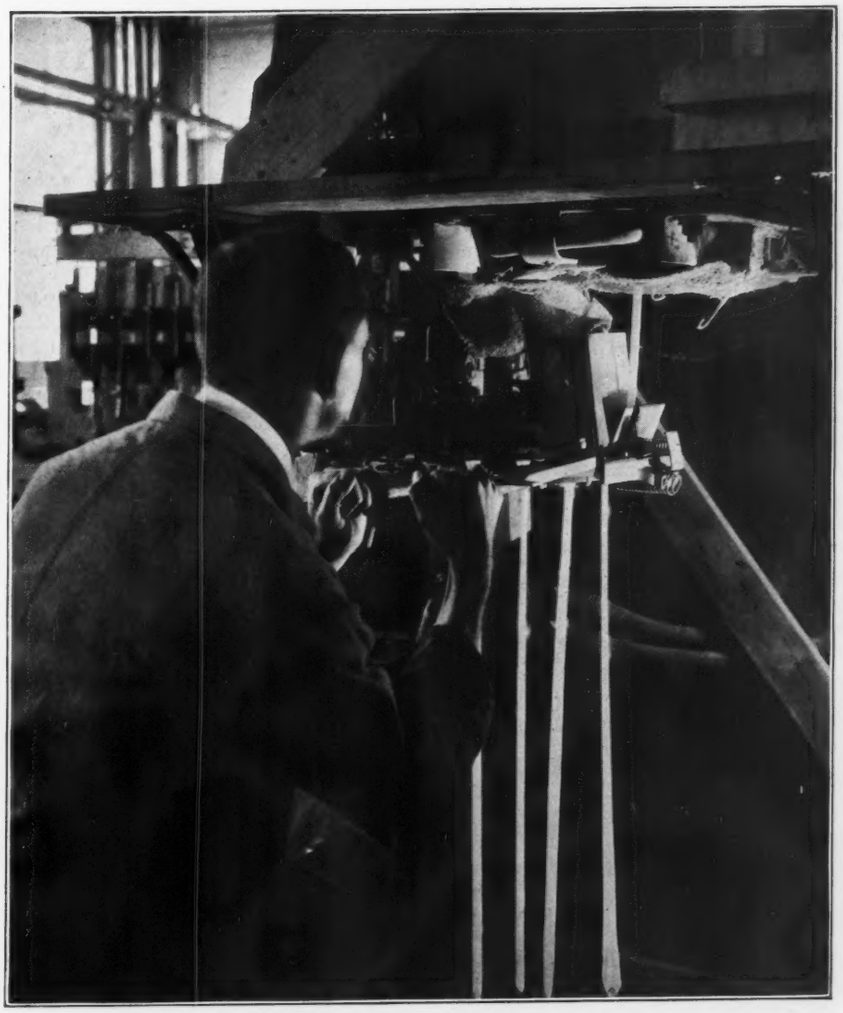
This apparatus is of recent development and has made possible a much wider use of fused quartz. Quartz made by this process will transmit light waves as low as the 1850 A line in the ultra-violet.

small. This slug is now placed in another graphic crucible which is suspended in a vertical carbon tube furnace. A graphite pistol which just fits the crucible is placed on top of the fused quartz slugs and a weight is placed on top of a plunger attached to the piston. The slugs are again brought to fusion, the bubbles are practically collapsed and by the action of the weight the quartz is extruded in the various forms, such as rods, tubes, ribbon, etc. This material is practically free from bubbles, but because of limiting dimensions it may become necessary to re-work some of this, which is accomplished by the usual bench methods with an oxygen-illuminating-gas flame.

When it is desired to obtain large blocks as free from bubbles as the tubing, cane and ribbon, another operation is necessary. As before, the quartz is fused in a vacuum furnace which, however, is also designed to withstand very high pressures. As soon as the material is fused, the vacuum valve is closed and the pressure in the tank is brought up to some value, depending on the object in view, in less than a minute. This pressure collapses the bubbles and makes it possible to obtain very large slugs freer from bubbles than many kinds of the best optical glass.

Previous attempts to reduce the bubbles by continued heating above the melting point resulted, after a certain stage, only in excessive loss of silica by volatilization. We have fused quartz at initial pressures of 600 lb. per sq. in., atmospheric pressure, and less than ½ mm. of pressure. In the first case the mass was practically opaque; at atmospheric pressure it was considerably improved although much inferior to the present quality of quartz; and under vacuum conditions a large mass can be produced, which from the standpoint of number of bubbles is very satisfactory.

Not the least of the difficulties encountered in this development has been that in connection with the furnace equipment. The vacuum furnace in particular had to be greatly changed and enlarged with the result that we now have probably the largest vacuum furnace in daily use capable of operating at low pressures. Then, in addition to this, the furnace had to be so constructed as to withstand repeatedly on the cover a total pressure of over 1,000,000 lbs. (about 600 tons), and of course as the size of the furnace increases these difficulties are multiplied. Special attention must be paid to the design of the resistor unit, to the thermal insulation, to even heat distribution, to the cooling of the terminals, and to the many other factors



CLEAR FUSED QUARTZ IN THE PROCESS OF MANUFACTURE

By this new process it is now possible to make quartz tubes, from eight inches to 30 feet in length, having comparatively few bubbles and these widely separated.

which presented themselves in the use of these two extremes in pressure.

When the quartz crystal is heated between 500° and 600° C., it undergoes a remarkable physical change, cracking into small pieces, sometimes with explosive violence. This is due to the difference of coefficient of expansion along the two axes subjecting the crystal to great strain, and to the decrepitation caused by the presence of water and liquid carbon dioxide held in vast numbers of minute cavities throughout the crystal. The only advantage therefore in using large crystals for fusing lies in the greater ease of keeping the charge free from foreign material before the different particles begin to coalesce.

Hereaus has heated crystal quartz in very small pieces, about the size of a nut, very slowly so that no cracking occurs and, consequently, no bubbles are included in the vitreous pieces. Herschkowitsch, on the other hand, has arrived at about the same result by accelerating the heating process so that a film of vitreous material is formed on the outside and prevents air from penetrating to the center, even though cracks may develop. As a matter of fact these processes, while interesting, are subject to very sensitive control and are impractical where large masses are to be fused.

To obtain masses quite free from bubbles, it has been found best to raise the temperature rapidly to 1400° or 1500° C. at which point the pieces begin to coalesce. At about 1750° C. the quartz is thoroughly fused though it is still very viscous. In fact, the viscosity is high even though the temperature be well over 2000° C. Vaporization of fused quartz is rapid at 1600° and at 1750° C. the loss due to evaporation is very great. Further increase in temperature results in no great gain in fluidity.

The difficulties of obtaining perfectly homogeneous fused quartz free

(*Continued on page 152*)

CO-OPERATIVE RESEARCH AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

By GEORGE B. HAVEN, '94
Professor of Machine Design, Massachusetts Institute of Technology

DURING the last days of his life our much beloved and lamented President Maclauren received a wide vision of the possibilities of co-operation between industrial concerns and the Institute of Technology. Before his death he set this forth in enthusiastic terms and enlisted the interest of numerous industries in this direction. He recognized the fact that the rapid advance of industrial development was in large measure the result of the application

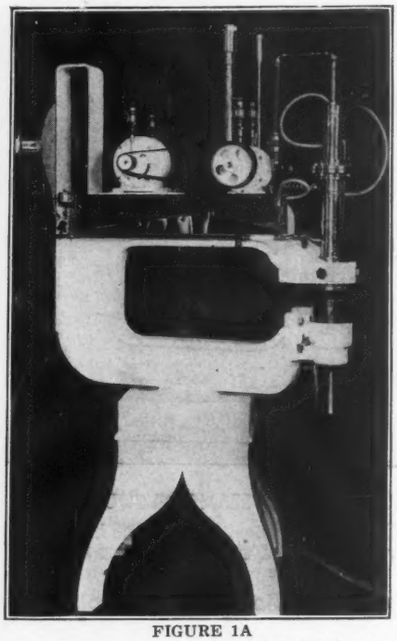


FIGURE 1A
MACHINE FOR MEASURING POROSITY
Mounted on the top of the machine is a low pressure Gramercy valve, which furnishes the low pressure air for the orifice pipe.

of scientific agencies for developing new methods as well as improving existing processes.

From this beginning there has sprung up a continually increasing number of industrial relations at the Institute whereby numerous concerns bring their questions here for solution or at least for suggestion and comment.

Needless to say, this has extended the Institute's usefulness to a very great degree and has resulted in cordial relations and a true co-operative spirit between the School and very many manufacturing organizations.

About five years ago the Albany Felt Company, Albany, N. Y., became interested in the solution of certain novel and difficult questions relative to the manufacture of heavy woolen felts and jackets for use in paper machines.

These fabrics, made of the finest wool, are frequently woven to widths of twenty feet or more. Their use upon the cylinders of the paper machine requires shrinking, fulling and finishing with unusual accuracy and the resultant strength and porosity is of very great importance.

Since, aside from its tensile strength and enduring qualities, porosity is one of the chief requisites of these fabrics, it is evident that some means of measuring and standardizing the porosity of various weaves and weights is desirable. The question of measuring this quantity was therefore brought to the Division of Co-operation and Research and they were asked to devise a method, and if necessary apparatus, for denoting the relative porosity of various felts. It was desired to measure the porosity of every felt after fulling and finishing it and to sell with the fabric a plot or diagram representing the amount and variation of this quantity from selvage to selvage. Since the felts were supposed to be subject to water porosity in their actual use in the paper machine it was natural that water should be used as the medium by which the porosity should be measured in actual practice. Messrs. Wilson and Taylor of the Division Staff at that time took this matter in hand and at once established the fact that tests upon a finished felt with water as the medium of measuring porosity would injure its finish locally and interfere, in a measure, with its use in the paper machine. Measurements of water porosity were therefore discarded and the question was laid aside for two or three years.

Meanwhile the Albany Felt Company became impressed with the fact that they should install modern and well-equipped chemical and textile laboratories in their own plant and build up eventually a staff of trained experts who could solve under their own roof the various research problems relative to paper and wool felts.

The author of this paper was therefore invited to make numerous trips to Albany to oversee the construction and equipment of such laboratories. A large, well lighted engine room, the use of which had been discarded sometime since in favor of electric driving, was remodeled for the purposes of these laboratories. The engine foundation was utilized in a very desirable manner to support testing machines, fine balances, etc. The equipment of the Textile Laboratory was very complete, including testing machines for yarn, light and heavy fabrics, a compressed air system, electric oven, automatic control of the atmospheric temperature and moisture, and a full complement of the

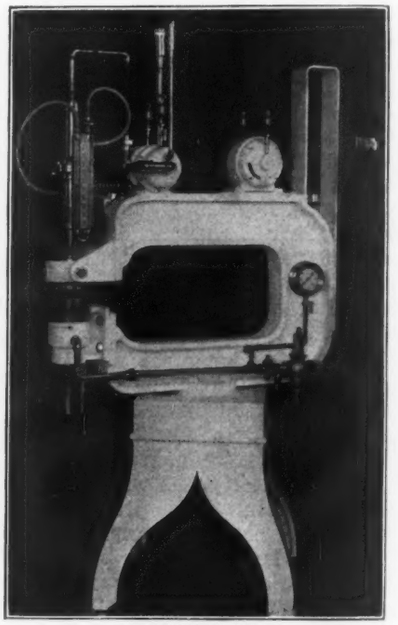


FIGURE 1B
MACHINE FOR MEASURING POROSITY
The U-shaped frame is rigid and adjustable and carries in its lower portion a pneumatic piston and hollow rod.

apparatus used in preparing, conditioning and testing fabrics.

The Chemical Laboratory was equipped with the usual perquisites, compressed air, distilled and tap water service, direct and alternating current electricity, ventilated hoods, isolated balance room, coal testing room and photographic dark room. The transformation of the old engine room into these modern and useful laboratories consumed about a year and a half.

Naturally after equipping these laboratories the company wished to initiate a research staff and for this purpose called from the Institute Textile Laboratory, Mr. Harold F. Hedberg and Mr. Carl C. Gordon, a master's

(*Continued on page 154*)

RECENT BOOKS

This department is conducted by the members of the Institute Library staff. All books referred to may be found in the Institute Library. As the space is limited, only a brief outline can be given, but it is hoped that this page will prove helpful to those interested in the acquisition of a reference library.—EDITOR.

BUSINESS

The Technique of Executive Control, by Erwin Haskell Schell, Assistant Professor, Business Management, Massachusetts Institute of Technology. McGraw-Hill Book Company, Inc., New York, 1924. 130 p.

Professor Schell aims to offer in this book a constructive analysis of executive conduct and a guide to executive straight thinking, and he has produced a manual that should be stimulating and helpful not only to students and employees, whose aspiration is ultimately to find themselves in executive positions, but to seasoned executives as well.

Since all business has its basis in human relations Professor Schell very properly places among the first of the traits essential to executive success an innate interest in and affection for people, and in his presentation of his subject he nowhere allows the reader to forget that the successful executive is the one who utilizes effectively the characteristics of human nature, which are fundamentally the same in employer and employee.

Constant use is made of the principles of the case system by placing before the reader specific simple problems and situations which necessitate executive action or decision, leaving the reader to work out his own conclusions in the light of the suggestions and illustrations which have preceded.

The scope of the book is well indicated by such chapter titles as "Executive Tools," "Executive Control," "Executive Stimulation," "Executive Duties," "Difficulties with Subordinates, Superiors and Associates." The text is everywhere clear and direct and carries valuable suggestions concerning executive conduct and action on nearly every page.

ARTHUR D. LITTLE, '85.

Financial Organization and Management of Business. New York: Prentice-Hall, Inc., 1924. 723 p.

Based upon the author's course in corporation finance given at the School of Commerce, Accounts and Finance of New York University, but prepared with the casual reader and business man also in mind. Aims to give a thorough knowledge of the subject and insight into underlying principles.

Management's Handbook, edited by L. P. Alford. New York: Ronald Press Co., 1924. 1607 p.

An exceedingly comprehensive handbook of working information for executives of manufacturing plants. Each subject is dealt with by a specialist. The term "management" is used in its widest sense, to include administration and organization.

Elements of Cost Accounting, by A. B. Manning. New York: McGraw, Hill Co., 1924.

An attempt to present the subject of cost recording in an illustrative manner, much as elementary bookkeeping is usually taught, with problem data and graphic charts.

ELECTRICAL ENGINEERING

Industrial Electricity, by William H. Timbie, Professor of Electrical Engineering and Industrial Practice. New York: Wiley, 1924. 735 p.

This new book by Professor Timbie presents the principles of the direct current electric, magnetic and di-electric circuits, direct-current motors, generators and measuring instruments, and includes a chapter on vacuum tubes and gaseous conduction.

The book is essentially a text-book, and the explanations are given in a clear and complete manner. While no mathematics beyond simple algebra is used, phenomena which would require higher mathematics for their complete explanation are not omitted but are discussed in a qualitative way. Although "Industrial Electricity" is designed particularly for the use of electrical workers and secondary technical schools, it has considerable value as a reference book for students at the principal technical school and colleges to supplement the necessarily briefer and more concise explanations given in the more advanced texts.

L. F. WOODRUFF, '18.

Electrical Measuring Instruments, by C. V. Drysdale and A. C. Jolley. In 2 vols. v. 1: Commercial and Indicating Instruments. London: Benn, 1924. 440 p.

This is the first volume of a treatise on the design of electrical measuring instruments, very complete in its data and excellent in its make-up.

Storage Batteries, by G. W. Vinal. New York: Wiley, 1924. 402 p.

A general treatise on storage batteries and their engineering applications in which the subject is brought well up to date.

CHEMICAL ENGINEERING

Aniline and Its Derivatives, by P. H. Groggins. New York: Van Nostrand, 1924. 256 p.

Believing that the chemical engineer should understand more of the business background of industrial chemistry, the author, using the production of aniline as a vehicle, has shown how the principles of chemical engineering are actually applied in a well-organized plant. There are tables of constants and properties and chapters on aniline poisoning and on the action of acids and alkalis on engineering materials.

CHEMISTRY

Chemistry in the 20th Century: An Account of the Achievement and the Present State of Knowledge in Chemical Science. Prepared under the guidance of a committee representing the scientific societies (of Great Britain) with Dr. E. F. Armstrong as editor. London: Macmillan Co., 1924.

This volume is made up of articles on such special phases of recent chemical investigation as colloid chemistry, catalysis, chemistry in agriculture, physical chemistry, etc., contributed by British men of science who are specialists in those fields.

PHYSICS

Die Roentgenstrahlen, by Paul Cermak. Leipzig: J. A. Barth, 1923. 130 p.

(*Continued on page 162*)

MONTHLY NEWS

Marine Diesel Design Tendency. The recent passage of the Ship Conversion bill has given an added impetus to research and experimental work with Diesel engines, both in this country and abroad. The tendency of the changes manifests itself in the development of double acting and opposed piston types of engines. The case of two cycle vs. four cycle still rages although existing production, making use of recent port-design development, seems to favor the two-cycle design. There is a limit to the size of cylinder that is practical, believed by Diesel experts to be around thirty inches, and for this reason, single acting six-cylinder four-cycle plants developing in excess of 2000 B.H.P. are scarce. A double-acting four-cylinder two-cycle plant to develop in excess of 4000 B.H.P. is now in the course of construction and test.

One of the prime objects of present research is to develop the required power in an engine of approximately the same or smaller size and weight as a marine steam engine, thereby requiring the minimum of hull alteration. Great attention is being paid to the distribution of power impulses in order to even out the torque in the propeller shaft, thereby allowing smaller shafting or decreased insurance rates.

Experiments are being carried on to allow the engine producers to cope with situations requiring enormous horsepower per shaft by the use of electric coupling. Theoretically the weight of the electrical units would be compensated for by the saving in weight per horsepower of a multiple Diesel unit installation, because while the power increases roughly as the square of the bore, the weight increases roughly as the cube of the bore. This opens fascinating possibilities relative to battleship propulsion. —*Motorship.*

What Happens When Dynamite Explodes. Big dynamite blasts are more and more frequent items of news. Charges of dynamite are buried deep in the face of a cliff, an electric switch is turned, there is a deafening roar, and thousands of tons of rock come crashing down. What, the inquiring observer asks, produces this explosion? What actually happens when dynamite explodes?

To answer this question it is necessary to explain briefly what dynamite is. Reduced to its essentials, dynamite is a mixture of nitroglycerin with wood meal and nitrate of soda or nitrate of ammonia, or both. Nitroglycerin, in turn, is composed of several different elements, the molecules of which are grouped in such a way as to form a heavy, oily, yellow liquid. Now these same molecules are capable of arrangement in other groups to form several different substances instead of the one, and the bonds which hold them together in the particular arrangement which makes nitroglycerin are very weak.

Consequently, when the electric current sets off the detonator imbedded in the dynamite, and this imparts a sharp shock and very high temperature to the nitroglycerin, the bonds between the molecules which compose the nitroglycerin break down. The nitrogen and some of the oxygen remain free, both of them gases, while the other molecules instantly combine to form two compound gases, carbon dioxide and water vapor. The breaking down of the nitroglycerin and rearrangement of its molecules generates a great deal of heat, enough to raise the temperature of the gases to 6,300 degrees F. or thereabouts, and this high temperature causes the other ingredients of the dynamite to decompose into gases, or to burn, with the release of still more heat. All of this takes place in a single instant and the highly heated and rapidly expanding gases, which would normally occupy a much greater volume than the dynamite, exert a sudden tremendous pressure on the walls of the bore-hole. The rock gives way, and the escaping gases set the air into violent vibration.—*The Excavating Engineer.*

Million-Volt Laboratory. California's precedence in the development of high tension transmission to a point where 220,000 volts is being successfully employed by two of the largest utilities in that state has been a contributing factor in the establishment at the California Institute of Technology, Pasadena, of the only million-volt laboratory outside of those maintained by the two large manufacturing companies on the East Coast.

The Southern California Edison Co., sponsor for the laboratory, ordered the equipment from the Westinghouse Electric & Mfg. Co. and set it up, using a cascade connection developed by Royal W. Sorensen, Professor of Electrical Engineering at the California Institute of Technology.

The equipment consists of four 250-kva., 250,000-volt units. Unit No. 1 is on the floor. Units 2, 3 and 4 are each upon steel frameworks at potentials of 250 kv., 500 kv. and 750 kv. above ground, respectively. These frameworks are separated by insulator stacks, each stack being made up of 7 units of 45,000 lbs., contains 2,950 gallons of oil and required approximately 11,000 lbs. of iron and 60,000 feet of wire to construct it.

Dredge Cutter Head that Handles Rock. Unusual difficulties were encountered in the dredging incident to the improvement of Tampa Harbor, Florida. As the depth of the dredging increased, greater percentage of rock was encountered and to meet this situation a unique type of cutter head was evolved and first used by the pipeline dredge Barnard.

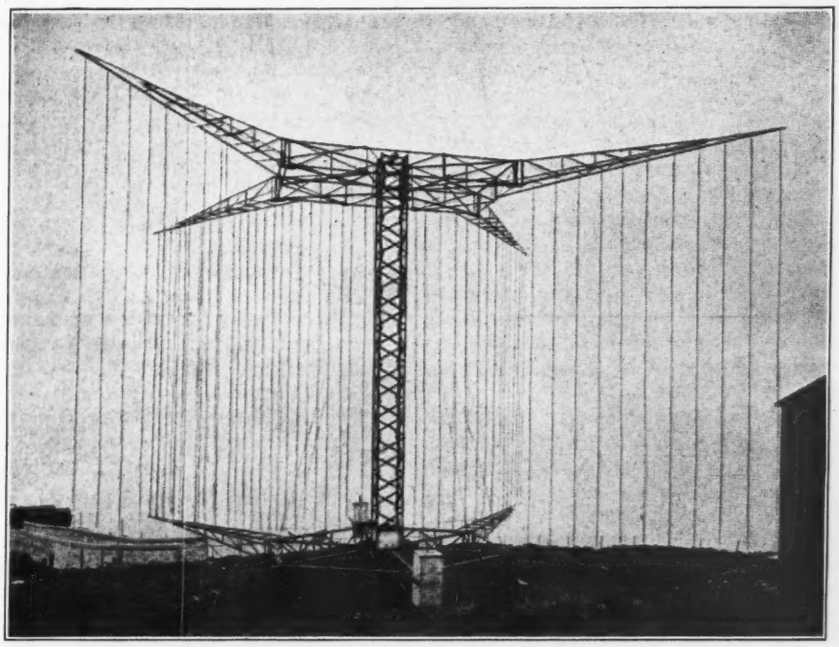
This cutter head has five blades shaped so as to closely approximate a parabolic conoid. This insures that the maximum length of blades will engage the material at the average depth of dredging. The interval between successive engagements of the blades is small, thus minimizing shock and vibration. The angle of advance is 59 degrees and the curvature of the blades tends to draw the material towards the 23-inch suction opening. Each blade is provided with five removable 100-pound teeth and a cutting edge. These parts are of manganese steel. Screens are placed between the blades to regulate the size of material going to the pump. The cutter bed weighs five tons and is keyed to a square tapered shaft.

The cutter head revolves at about 12 r.p.m. and is fed into the bank at a depth of eight inches. The gross cost is about $1 per cubic yard and many private companies are now using this head for even more abrasive rocks than were encountered in Tampa Bay. *Military Engineer.*

New Radio Aids for Saving Ships. As soon as the radio compass for detecting the direction of radio waves was invented and applied to the use of ships at sea, it became possible to construct at dangerous points on the sea coasts of the world a set of radio lighthouses to serve as adjuncts to the ordinary lighthouses, which have been for more than twenty centuries the chief reliance of a mariner as he approaches port.

A recent improvement in these radio lighthouses consists in sending out, not merely a radio signal that goes broadcast in all directions, but an actual radio beam that goes only in one direction, like the beam of a searchlight. The transmitter employs the reflection principle for radio waves, as developed by Senator Marconi. The wire cage that serves both as transmitter and as reflecting mirror is mounted on a central shaft so that it can be revolved. As it revolves, the "beam" of radio waves sweeps across the ocean surface, just as the beam of a revolving searchlight does.

The transmitter shown here has been installed at Inchkeith, on the coast of Scotland. It has been in operation for over a year and has been recently rebuilt to embody important new improvements. The region where it is installed is especially subject to thick fogs, and it is reported that the revolving radio lighthouse has already established its value, many times over, in the increased safety to ships and, more directly still, in the avoidance of delays due to fog. It is probable that these radio beam lighthouses will be installed elsewhere on many fog-bound coasts.—*Scientific American.*



THE NEW RADIO BEAM "LIGHTHOUSE"

The wire cage shown serves both as a transmitter and as a reflecting mirror, and is mounted on a central shaft so that it can be revolved. As it revolves, the beam of "radio" waves sweeps across the ocean surface.

Hudson Avenue Station. The Brooklyn Edison Company has recently placed in operation the world's largest central station. It develops 400,000 to 500,000 Kw. The turbines are designed for operation at 265 lb. gauge pressure, 200° F. superheat, and 1-inch absolute back pressure. Steam is extracted from two stages for heating the feed water. Each turbine operates a single generator rated at 50,000 Kw., 80 per cent p.f., 13,800 volts, Y connected. A closed air circulating system with water coolers is used.

The single conductor leads from the generator go directly to a single phase auto-transformer where the voltage is stepped up to 27,600 volts. Phase separation and phase insulation start at the generator terminals and continue throughout the switch house. Each generator with its corresponding auto-transformers is protected as a unit by an overall differential relay system in combination with a split conductor system. This gives complete protection against internal failures, in generator, auto-transformers and leads.

The auxiliaries are supplied with power from the main bus sections through house transformers. Twenty-seven thousand, six hundred volts was selected as the most economical transmission voltage as the station location, with only two streets available for duct lines, did not permit distributing the station output at 13,700 volts.—*General Electric Review.*

Gas Engines in Municipal Light Plant. Recently the Municipal Light plant at Basin, Wyoming, was changed over from gas-fired steam boilers and non-condensing engines to internal combustion engines, using natural gas as fuel. With the old steam equipment, the gas consumption was 150,000 cu. ft. per day, costing $22.50 for a power output of 1,100 Kw.-hr. With the installation of two 165 h.p., four-cylinder, four-cycle, natural gas engines, one belted to a 125 kw., 2,300-volt, 3-phase, 60-cycle generator and the other to a 90 kw. machine, a saving of 80 per cent in fuel consumption was obtained. The net saving in fuel and lubricating oil, due to the change, was $560 per month.—*Power.*

Large Non-Metallic Gears Made for Paper Machine. "Micarta gears 6 feet in diameter, and believed to be the largest non-metallic gears yet manufactured, have been built recently by the Western Gear Works of Seattle. The gears will be installed on the drying section of a 164-inch Bagley-Sewal paper machine.

The spider for the gear was cast in one piece with a flange on either side, which was machined so that the micarta segments would fit snugly in the rim.

The gears will replace cut, cast-iron gears on the drying section, for the purpose of eliminating the noise and vibration produced by the metal gears at high speed. The normal operating speed will be about 1,200 feet per minute. Thus a continuous sheet of paper 12 feet wide comes off the machine at a speed of 1,200 lineal feet per minute.

The temperature of the atmosphere in which these gears will operate is about 100 to 150° F. due to the proximity of the steam heated dryer rolls. —*Western Machinery World.*

New Type Electric Locomotive. A new type electric locomotive, using oil for its fuel, the first of its kind ever manufactured in America, has been built jointly by the General Electric Company and the Ingersoll-Rand Company.

The power plant equipment consists of a 300-horsepower oil engine directly connected to a 200-kilowatt generator. The motive power consists of four HM-840 motors, one of which is geared to each of the four axles. The unit has a total weight of 60 tons on the drivers.—*Western Machinery World.*

EDITORIALS

FUEL, GAS AND CERAMIC ENGINEERING

In a recent interview, President Stratton stated that preliminary steps were being taken to establish a course in Ceramics and another in Gas and Fuel Engineering at the Institute. The details of these courses have not been settled, but they will be primarily for graduate students.

When we consider that the ceramic industry is the fourth largest in the United States and that in most industries the cost of fuel is half the cost of production, the magnitude of the field open to men completing either of these courses becomes evident. At present there are few authorities on either subject; it is difficult to find experts in such fields.

The tendency has been to group courses of study under the recognized fields of engineering rather than under the industries to be served. These courses will consist of a systematic grouping of the fundamental engineering, chemistry and physics involved, together with a study of the technical conditions and problems of each. It is with a view to providing an opportunity for those who wish to specialize in these branches of engineering that the proposed courses are to be established.

DR. CHARLES FABRY

Seldom has the Institute been more fortunate than when Dr. Charles Fabry consented to give a series of twelve lectures on Optics and particularly on interference phenomena. Dr. Fabry is a professor at the Sorbonne, President of the Societe Physique de France, and Director of the Institute d' Optique.

Graduated from the University of Paris in 1898, he became a member of the staff at the University of Marseille, where he rose to the rank of professor. From Marseille, he went back to the University of Paris and continued his work in Optics, experimenting mainly in interference and its applications. He has developed a method of spectroscopic measurement and was the originator of the "International Standards."

L'Ecole Superieure d' Optique, of which Dr. Fabry is the founder and director, is a graduate school in theoretical and applied optics. Its purpose is to train men to design, produce and use optical instruments of all types, and the requirements for admission are that the applicants shall have received degrees in General Mathematics.

The courses of study cover practically every field in which optical instruments are used for precise measurements and also all the fields of science necessary to the design and manufacture of these instruments.

The first term's study covers such general subjects as the propogation of light, diffraction and the general theory of optical instruments. This is followed by lectures on astronomical, photographic and spectroscopic instruments. The more advanced work covers physical chemistry, optical physiology, the chemistry and technology of optical glass, the use of light in chemical reactions, spherical abberration and many other subjects. All of these lectures are given by prominent engineers and scientists.

Dr. Fabry's lectures, coming as they do, just as courses in Gas, Fuel and Ceramic Engineering are to be inaugurated, would seem to indicate that some time in the future, a graduate course in Optical Engineering would be established at the Institute. At present very few opportunities are offered by American universities for intensive study in this subject and the demand for specialists is becoming constantly greater.

SUPER-POWER

In a recent address at Springfield on the proposed government-owned super-power system, Mr. Guy E. Tripp made the following statement: "The belief in public ownership of super-power is in the main founded upon apprehension—a fear that such a great national public service in the hands of private capital would acquire so great a power that it could not be prevented from exploiting the public. The reply to that is that the present system of regulation of public service corporations has been proven to be sound, and that public interest, in fact, is already effectually protected; and, if any objectionable practices still remain, they can be readily remedied, while on the other hand a real danger to public finances and a real political menace lie in the government ownership and operation of a business, which in the case of super-power, might in ten years require an investment of $10,000,000,000. The idea of such a business being managed by government employees who have none of their own money at stake and are governed only by bureau rules and precedents, is overwhelming. It would not be a corporation depending upon economic laws and business checks for its guidance and limitations; and, as it would conduct a complicated industry which is still in the development stage, it would in all likelihood be an expensive experiment."

"Finally, if the public cannot trust their representatives to regulate a super-power system, how can it trust them to construct and operate it?"

This statement seems to conform to the general public attitude towards the construction and operation of large engineering projects under government supervision or ownership. It is deplorable that such should be the case, but after the recent oil scandals we cannot blame the public for being suspicious of any great outlay of public funds when the outcome is but problematical. Opponents of government ownership point to the war-time railroad administration and emergency fleet corporation as examples of its inefficiency.

If these were the only instances in which large engineering or industrial projects were directed by government employees, we should have to admit that the case against federal control were complete. However, we cannot lightly pass over the devotion and disinterested loyalty of many government engineers and scientists. We have innumerable examples of men, authorities in their particular lines, who have worked conscientiously and successfully in government service. The Reclamation Service has built some of the largest engineering and power projects in the West and at present the army engineers are doing a remarkable piece of work at Muscle Shoals. It may be that government ownership would be inefficient but we are not so cynical as to believe that the engineers put in charge of its construction and operation would suddenly throw off the high ethical standards of their profession and become the inefficient public servants pictured.

PETROLEUM

(*Continued from page 137*)

point of, say 150° F., it means that this oil is of such volatility that it will emit vapors in sufficient quantities to flash only when its temperature has been brought up to 150° F. If we had said that the fire point of this oil was 220° F., we would mean that the oil would flash and continue to burn freely only after it had been heated to a temperature of 220° or more.

In distilling oil, sensible heat must be supplied to bring it up to the temperature at which it will vaporize and, as in the case of water or any other liquid, an additional amount of heat must be supplied at this temperature to cause the change from the liquid to the vapor state.

The process of distillation was originally accomplished in shell stills and although somewhat modified in design today, this type of still is more or less a standard piece of equipment. Stills of this nature range in size from a cubic capacity of 300 barrels to 1,200 barrels. They are generally supported by riveted lugs along the side and are suspended over a fire box in much the same manner as fire tube boilers, with which we are all familiar.

At first distillation was carried out by simply filling the still with crude and applying the heat to vaporize the oil to the required extent, drawing off the residuum when the proper separation had been made. The operation known as a "batch" distillation is still used for certain purposes but not, as a rule, for crude work. Later the "semi-continuous" method developed which consisted in starting the distillation as the crude was being pumped in and stopping only after the still had accumulated as much bottoms or residuum as could be handled.

At present, the distillation is usually carried out continuously; that is to say, a series of stills are built next to each other in a battery and flow lines are provided from one to the other. The oil is pumped into the first still where it is submitted to a moderate heat and certain portions of it are vaporized and condensed. The residuum from this operation as it accumulates, flows into the next still where it is submitted to a higher temperature and so on down the line until the last still has been reached, where the residuum drawn off is of the nature required and all the desired volatile products have been extracted from the oil.

Further modification of stills, however, led to the development of what is known as a pipe still, which consists briefly of a coil of pipe in a parallel or series, through which the oil is pumped and heated and flows to a large expansion drum where the hot oil is released and allowed to vaporize. The vapors are then carried out to the condenser in the usual manner and distributed in accordance with their nature and the residuum drawn off from the base of the expansion chamber.

The pipe still is more efficient than the shell still and is rapidly gaining ground. It is used very extensively for wet crude oil which, if charged into an ordinary still, is likely to cause boiling over or foaming since the water which is introduced into a mass of oil has a boiling point lower than most of the material surrounding it. It will immediately flash into steam.

Obviously taking the vapors straight off the still is bound to result in a great deal of priming and the distillates obtained from the operation then have to be redistilled to make them meet specifications. In the modern process of distillation, an apparatus, known as the fractionating tower, is interposed between the still and the condenser, and which serves the purpose of sorting out materials of different boiling points and permitting a closer separation of the products.

A fractionating tower consists of an upright shell, 30 or 40 feet in height and about four or five feet in diameter, in which there are "baffles" or perforated trays or other type of packing which cause the vapors to change their course on the way through, and as they cool in ascending the tower, the heavier or higher-boiling-point liquids condense out, allowing only the lighter portions to carry through. There is also an interchange of heat between the condensed fractions and the rising hot vapors which tend to strip the condensates of whatever volatile bodies they may contain. Obviously by regulating the temperature of the tower, it is possible to obtain products of different boiling points at various sections of the tower, and sometimes several "cuts" can be obtained at the same time, without additional distillation.

Certain types of crude oil will decompose upon being distilled, to the extent of making the color of the distillates darker and perhaps spoiling the properties of some of its constituents. This is obviated by injecting steam in the still which has the effect of agitating the contents and at the same time lowering the temperature at which the oil will vaporize, due to the fact that it shoulders part of the atmopsheric pressure and has the effect of creating a partial vacuum.

Another type of still used in refineries is one in which the distillation is conducted under pressure and which serves to "crack" or disintegrate a distillate to produce more volatile products such as gasoline.

There are many kinds of pressure stills, perhaps the most common being the Burton type which consists of a horizontal drum to which a series of tubes are hung in similar manner to a water tube boiler. The oil charged is heated and the vapors generated are retained until the still has attained a pressure of about 100 pounds, and the distillation carried out under this pressure drawing out the vapors through a condenser also kept under pressure. The result of the operation is a gasoline distillate known as "pressure distillate" and a residuum known as "pressure still tar."

It is difficult in the limited space available to go into every phase of refining, but it may be worth while to digress for a few moments to describe the effect of cracking oils. We have seen that in the distillation of the crude oil the gasoline was merely separated by distillation; in other words, it existed in the crude and the distillation simply extracted it.

It has been known for many years that if oil were submitted to a temperature beyond its normal boiling point, it would decompose or break up into compounds having respectively higher and lower boiling points than the original charge. All of the cracking methods applied today take advantage of this fact and the various processes in existence are simply different methods of accomplishing the same thing.

Cracking processes can be generally divided into two chief classifications, namely, vapor phase and liquid phase. In the first, the oil vapors are superheated after they have been entirely vaporized, while in the second category, the oil is treated, as the name would imply, in the liquid state.

Although both methods produce low boiling hydrocarbons which can be classed as gasoline since they have boiling points of that range, the products obtained vary substantially in chemical composition. The compounds produced by vapor phase cracking are very highly unsaturated and contain a large percentage of chemical compounds known as olefines, while those obtained by the liquid phase method have materially less of these compounds present.

The vapor phase methods are not generally employed in refinery work

(*Continued on page 156*)

AERIAL PHOTOGRAPHIC MAPS

(*Continued from page 141*)

sion. Valleys, ravines and precipices, and even the smaller gulches appear as if carved into the earth's surface. Actual differences of elevation cannot be determined through mere stereoscopic vision, but an excellent conception of relative differences of elevation may be so gained.

Time required. Inasmuch as aerial photography work cannot be undertaken except on perfectly clear days, it will be obvious that flying operations must be carried on at intervals as the weather permits. Under favorable conditions from 60 to 80 square miles can be photographed in one day at a scale of say 800 or 1,000 feet to one inch. In order that all photographs shall be of good definition and have the necessary overlap, it may be required to repeat the photographic work in whole or in part until satisfactory results are obtained. As sufficiently clear days in the eastern United States do not occur oftener on an average, than once in seven, it may take many weeks to complete the photographing of an area of several hundred square miles. Clear days, suitable for aerial photography, occur oftener in the fall than at other seasons, and in some parts of the west, clear weather is more frequent and favors this class of work. The assembling of the photographs in final map form involves several distinct operations calling for special facilities and a high order of skill. It takes about thirty days to complete an area of 100 square miles at an 800 or 1000-foot scale.

Enlargements. Enlargements of aerial photographs are recommended for use wherever a large scale is needed for visualizing details. It is much cheaper to enlarge to a required scale than to make the original exposures at such scale. It is common practice to take photographs at a scale of 800 feet to one inch, which, with a 12-inch focal length, requires the airplane to be flown at an altitude of 9,600 feet above the ground (a desirable height for such work), and to enlarge the prints to 400 and even 200 feet to one inch. A four-diameter enlargement is usually the limit in such cases, although as high as eight-diameter enlargements have been used in actual practice with satisfaction.

Types of Maps. Two distinct types of maps have come into use for engineering purposes, each of which offers special advantages for certain purposes. The first is the "aerial photographic map" sometimes spoken of as "mosaic map." It is made by joining a large number of vertical photographs, first brought to a common scale, so as to produce a continuous photographic representation of a portion of the earth's surface. Such a photographic map mounted on heavy composition board, or on cloth, affords an exceptional means for studying the configuration of the ground, and portrays a wealth of detail that cannot possibly be embodied in any map made by ordinary surveying and drafting methods except at the expenditure of inordinate time and money.

In flat or slightly rolling country such a map can be constructed with a high degree of accuracy, but where the terrain is hilly or rough, the images of elevated objects located some distance away from the centers of the photographs will appear slightly displaced from their true positions due to perspective. Such displacements are unavoidable, and while many of them can be eliminated by selecting the central portions of the photographs in constructing the map, it is physically impossible to eliminate all of them except by going to great expense in taking additional photographs. However, where necessary, the exact amount of such displacement can be determined for any given object by descriptive geometry.

The experience, had to date with such maps, shows conclusively that in spite of these shortcomings they are adapted to many practical uses, and engineers properly advised as to the nature and extent of the displacements have used and are using such maps with much satisfaction.

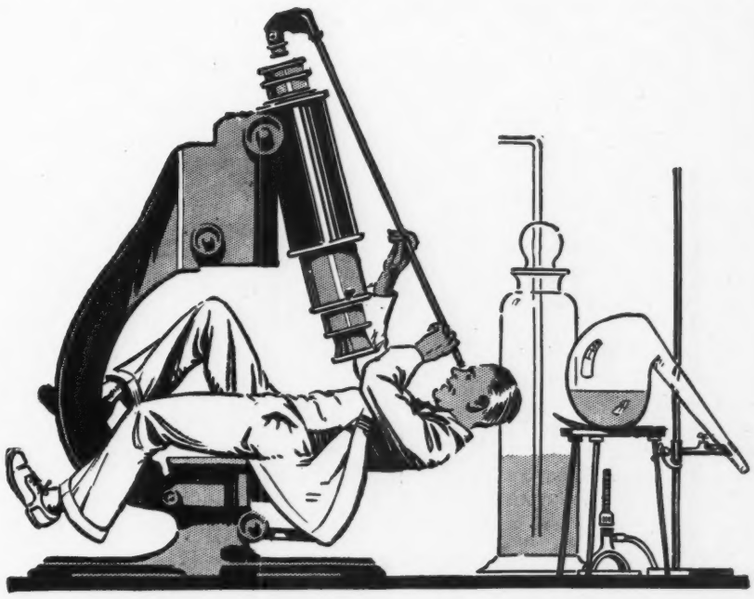
The second type of map, known as the "aerial line map" is produced by transferring to tracing cloth the more important features portrayed in the aerial photographs. It resembles in many respects the ordinary traced map produced by engineers or surveyors as the result of ground surveys, but differs from the latter by being more complete as regards detail and usually by being more accurate. Its use is especially recommended whenever areas are to be covered with contours, and where accuracy requirements are such as to make objectionable the presence of displaced images of elevated objects such as appear in "photographic maps."

To produce an aerial line map vertical photographs are taken in much the same manner as for a photographic map. Less attention need be paid to photographic quality, however, and so long as the pictures are clear, so as to permit of visualizing all features of importance, it is immaterial what time of day or season of year they are taken. Therefore, the aerial photographic work will be somewhat less costly in the case of an aerial line map and usually require less time.

The principal advantages offered by the line map are the elimination of errors inherent in vertical photographs, and the production of a map as nearly free from inaccuracies as is within the reach of practicability. The process is as follows: The aerial photographs, either at their original scale or enlarged, are taken into the field by surveyors, and contours are located directly on them by the ordinary method of stadia surveying. This operation is greatly facilitated by reason of the fact that the photographs show a large amount of detail that assists the surveyor in locating his instrument stations and guides him in sketching the contours. The 18- by 24-inch plane table and standard alidade have been found best suited for this work. The operations are so simple that any experienced surveyor can learn them in a short time. As the field work progresses, all contour lines and other features that are to appear in the finished map are inked in on the photographs, and this should be done in the field where errors and omissions discovered during the inking process can still be corrected. The pictures are then sent to the office to be traced off onto tracing linen. This work requires specially trained men. The first step is to lay out the ground control, and then to work out the "radial control," a system of paper triangulation derived from the photographs themselves, and fit this radial control to the ground control. This establishes the correct geographical position of the center of each photograph and also a number of control points by which the photographs can be oriented. As the work of tracing off the detail from the photographs progresses, the control points referred to are used in eliminating: (*a*) errors due to differences in scale of successive photographs; (*b*) displacements of objects due to material differences of elevation; (*c*) distortions due to tilting of the camera at instant of exposure.

The map, when finished, shows all objects that were drawn in ink on the photographs, together with such standard lettering, conventional signs and titles as may be required. Blueprints can be made in the usual way, and the map filed away in an ordinary map file. In conjunction with such a line map the original photographs will be

(*Continued on page 154*)



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CLEAR FUSED QUARTZ MADE IN THE ELECTRIC FURNACE

(*Continued from page 143*)

from striæ strain, bubbles, and double refraction must be apparent to anyone who has worked on this problem, and discouraging perhaps to those who have tried to buy such material. It is a little too early to state in what quantities such a product can be produced, but we have manufactured quartz of this quality which contained only two or three bubbles visible to the eye. This quality, however, has not as yet been placed on a commercial basis.

The fact that for a great many purposes clear fuzed quartz can be used up to 1000° C. without injury; that its coefficient of thermal expansion is so small as to make it almost negligible; and that it will transmit light rays even into the extreme utra-violet with very little absorption, gives to it a great utility value—not only to the scientist but the manufacturer as well.

The specific gravity of clear fused quartz is 2.21. Its coefficient of thermal expansion is 58 by 10-8 which is about 1/17 that of platinum and 1/34 that of copper; so small that a rod of quartz one meter in length will expand only about six-tenths of a millimeter for a 1000° C. rise in temperature. The small probability of fracture under sudden changes in temperature, because of this property, makes it especially desirable for many uses. Furthermore, where it is used as a mirror in reflecting telescopes this very small expansion or contraction with change in temperature causes almost no distortion of the image and, consequently, much greater accuracy is made possible. This property also makes the grinding of a lens or mirror less tedious and costly, as it is not necessary to await the cooling of the shape in order to get the desired curve. It is possible to heat a tube of clear fused quartz, say 5/8 inch in diameter, to the melting point and plunge it into ice cold water without fracturing.

Its index of refraction for the *D* line is 1.459, and while its dispersion is higher than optical glass it is more constant because of the smaller effects due to temperature changes. If the rays which have entered are nearly parallel to a rod of quartz they are totally reflected internally and on account of this can pass around curves, unless too sharp. This property, coupled with a very small absorption loss, makes it possible to transmit light through very great lengths of curved rod or tubing with very little loss. A rod of this fused quartz one meter long will emit at one end about 93 per cent of the total visible light passed into the other end. For the better grades of optical glass the highest percentage transmitted under the same conditions is not more than 65 per cent.

The ordinary run of quartz made by this process and used in the fabrication of quartz mercury-arc lamps will transmit light wave-lengths as low as the 1850 A line in the ultra-violet. From the opposite end of the spectrum the heat rays also are transmitted with little loss. For example, if one end of a fused quartz rod 12 in. long is heated to incandescence, it will be found very uncomfortable to hold the finger over the other end, although one may comfortably grasp the rod a few inches from the heated zone.

Clear fused quartz is the only known material which can be obtained in

QUARTZ MADE BY BLAST FLAME
This method has been used for many years, but can produce quartz only in small sections.

quantity and which is transparent to ultra-violet rays. The medical profession is consequently utilizing this material more and more in its application of ultra-violet light for therapeutic purposes.

By the process here described it is now possibe to make tubes, rod, ribbon and cane in lengths of 30 ft. and in shorter lengths of diameters up to eight inches. Blocks have been made up to 11½ inches in diameter and 6 inches thick, having comparatively few bubbles, and these widely separated, comparable in general appearance to the best quality of optical glass. Such material is suitable for prisms, lenses and for use in instruments where the visible ray is an important factor.

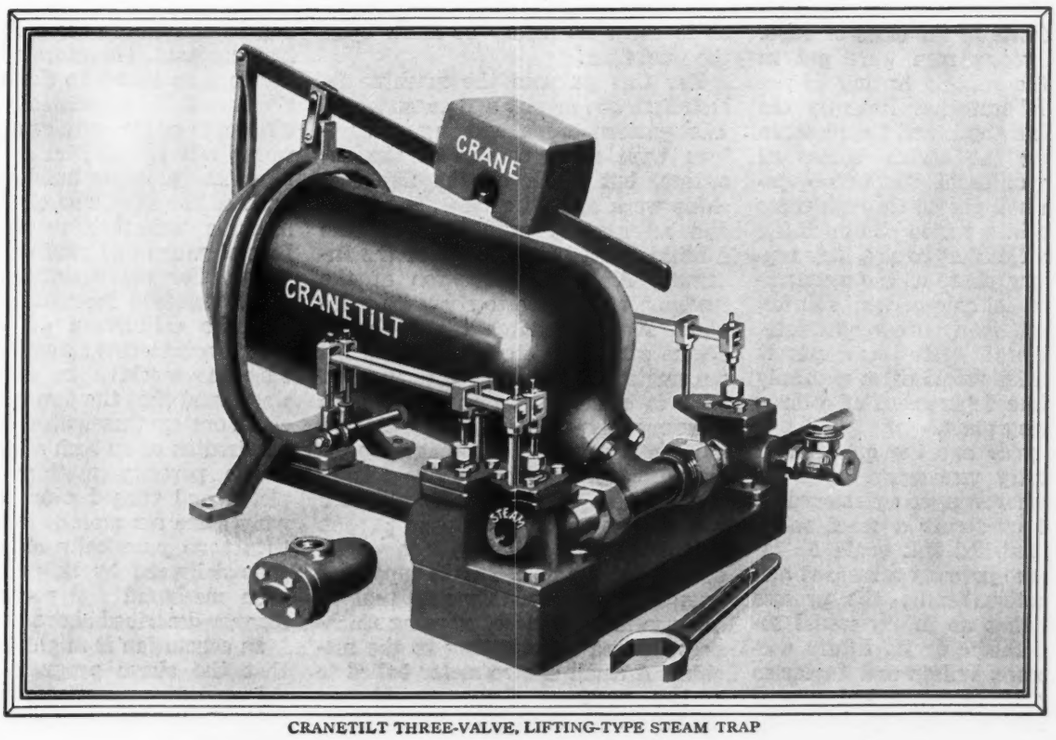
Constant progress in this development is being made and it is hoped that perfect homogeneity can be made the rule rather than the exception. It is expected that for most optical work this quality of the present material will be entirely satisfactory.

Fused quartz lenses of 4½ inches diameter have been for several months very successfully operated on test in motion-picture projection machines, using currents as high as 150 amp. and where glass lenses cracked almost daily.

It is well known that in the ordinary glass thermometers there is an appreciable lag in the glass, so that successive readings in a descending scale are inaccurate. To test the extent of this we have placed a standard glass thermometer and a quartz thermometer of our own construction in the same bath and raised the temperature to 515° C. and then lowered it again to 0° C. In this particular case the mercury in the glass came back to four divisions below the zero mark, whereas the mercury in the quartz returned exactly to its original calibrated mark at zero. While the capillary in the quartz tubing is not exactly uniform throughout its entire length, it is so uniform that a calibration of the tube over its whole length would eliminate any inaccuracies due to the slight non-uniformity.

As a standard of pitch the tuning fork is about the only appliance in use. Temperature changes affect the pitch of the hardened steel fork, however; and, what is more important, the work which has to be done in adjusting these steel forks to the desired pitch by grinding or otherwise working them results in changes in elasticity and dimensions that cause a disturbance of the pitch note. A tuning fork of quartz is not subject to these changes to any appreciable degree.

The New Element Hafnium, which was discovered recently by Coster and Hevesy, and which has some very interesting properties, is present in all zirconium minerals in appreciable amounts, ranging from 2 to 20 per cent. It is likewise present in so-called commercially pure zirconium oxide and salts of zirconium. It can be readily separated from the rare-earth elements, and resembles zirconium very closely in its chemical properties. It has a very high melting point and high power of light emission. The electron emission of the heated metal is very high, which suggests that possibly it would be of value in vacuum tubes for radio purposes. The element is abundant enough to make it available for commercial purposes.—*Eng. and Min. Jour. Press.*



CRANETILT THREE-VALVE, LIFTING-TYPE STEAM TRAP

WHAT IS A STEAM TRAP?

A successful steam trap should be a passageway for water and a barrier to steam. It prevents the loss of any steam while it disposes of the accumulated condensation from pipe-lines and headers. Or drains receivers, drip pockets or steam using appliances. It is automatic, performing its important function without attention.

Steam traps of the right type, properly arranged, will return hot condensation directly to the boilers as pure feed water. Conserving the "heat of the liquid" of this condensate, they effect large fuel economies. They are the most economical devices on the market for boiler feeding. Steam traps can also be used to draw condensation from low pressures or vacuums, discharging directly into a higher pressure, and metering the discharge if desired.

Cranetilt traps perform these and similar functions in many important power plants, in chemical plants, paper mills and oil refineries. Their operation is fully described in a Crane publication entitled "Condensation." We will be glad to send a copy to any engineering student who writes for it.

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CO-OPERATIVE RESEARCH AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

(*Continued from page 144*)

degree graduate in the class of 1923. These two young men were put in charge of the routine testing in the respective laboratories. Recently the author of this paper had the pleasure of reviewing the carbon copies of some sixty different research questions which had passed through these laboratories in a period of something over a year. Needless to say, they represented every phase of the mechanical and chemical side of wool fabrics, together with many other questions, some biological and some purely chemical, which would arise naturally in the welfare department of a large manufacturing plant.

About a year ago the question of fabric porosity was again taken up and the author was commissioned to design and construct a machine in which the finished felt could be inserted and the porosity measured and recorded automatically, the process being such that no injury would accrue to the fabric or its future usefulness. Messrs. Wilson and Taylor in their early experiments had proved by use of distilled water that porosity to air and water were definitely related for the entire range of fabric manufactured by the Albany Felt Company. In their report they embodied a carefully constructed plot showing accurately the relation between porosity to air and water for both thick and thin felts. Taking these plots as a basis it was decided to discard tests upon water porosity because of the injury to the finish by such tests and to conduct all future measurements with air as a medium. In this manner it was the expectation that tests could be carried out upon the finished fabric in such a manner as to cause no injury or mark upon the wool fiber.

For this purpose the machine illustrated was signed and constructed. The pattern work and heavy castings were made outside of the Institute, but much of the fine machine work and all of the assembling and adjustment were done in the Machine Tool Laboratories of the Institute. A brief description of the machine will suffice to show its principle. A rigid, adjustable U-shaped frame carries in its lower portion a pneumatic piston and hollow rod. This is connected as shown to high pressure air with gauges, reducing valve, etc., in the line so that the pressure necessary to clamp the felt in the machine may be nicely adjusted and measured. In the upper portion of the machine is housed a low pressure air orifice pipe. This is supported upon universal trunnions so that in no case is a fabric of varying thickness injured by clamping in the machine. A small electro motor belted to a low pressure Gramercy blower, mounted upon the top of the machine, furnishes the low pressure air for the orifice pipe. A large Bristol recording pressure gauge is attached to the chamber below the orifice and, for a check reading against the same, a long inclined tube gauge is similarly attached. The apparatus of Messrs. Wilson and Taylor was of this same general principle and their experiments proved conclusively that, if a given volume of air was driven through the fabric, the pressure building up upon the felt was an accurate relative measure of its water porosity. This is equivalent to saying that for low values the difference in pressure behind and before the orifice must be kept constant. Therefore a U tube was attached as shown to the orifice pipe. During all the experiments a standard difference of pressure of six inches of water was maintained in the orifice pipe. The pressure building upon the back of the fabric as clamped in the machine was then recorded by the Bristol gauge and read from the tube gauge. For the heaviest fabric this never exceeded four inches of water and the calibration of the Bristol gauge was to this amount. After putting the machine in commission it was found that the two gauges would check one another within two or three hundredths of an inch of water.

The porosity machine was completed and turned over to the company some six months ago and since that time practically all of the wet felts delivered by this concern have been measured for porosity in the manner described above.

In conclusion it might be remarked that the above program is a typical and very satisfactory one to both the industrial concern and the Institute. The company early appreciated the necessity of industrial research and naturally brought their questions at first to the Institute. Finding that the magnitude and importance of this work would warrant further effort and outlay upon their part, they sought, with the Institute's advice, to build and equip first-rate laboratories. Very naturally, therefore, they applied to the Institute for a staff, not only thoroughly familiar with their previous work here but at the same time sufficiently trained to carry out a continually expanding future program.

AERIAL PHOTOGRAPHIC MAPS

(*Continued from page 150*)

found of constant value for reference and for stereoscopic study.

It is important to note that an aerial line map is made from the original photographs direct, and not by tracing off a photographic map of the mosaic type. If the latter were done the line map could not be freed from the displacements appearing in the photographic map, nor would it be practicable to draw contours in the field on a photographic map without the latter suffering considerable damage in handling. Besides, the cost of first making the photographic map would not be warranted.

Cost. It has been found from practical experience that an aerial line map with contours, say at a scale of about 800 or 1,000 feet to one inch can be made at approximately half the cost of making a map in all respects similar by ground surveying alone. The principal saving in cost is effected by the greater rapidity with which contours can be drawn on a photograph. After a little practice, surveyors can usually cover from two to two and a half times as much ground in a day by this method as by ordinary plane table surveying with a sheet of blank paper.

Generally speaking there is nothing cheap about aerial photographic surveying, and many engineers have been greatly disappointed at its cost. It is a fact, nevertheless, that aerial surveys are cheaper than ground surveys, and that they make available more information for the amount of money expended than is possible by any other method.

Excavating by Explosives Power

DIGGING in the earth has been practiced by mankind for centuries. First for food, then for objects of utility, and finally for subterranean space—digging on a larger scale ultimately become *excavation*. But up until 125 years ago excavating work was done by primitive hand-labor methods.

The modern engineer finds in explosives a mighty power to dig foundations and to drive tunnels economically and efficiently. City excavation work particularly requires the highest degree of skill in the use of explosives because of the safety factor in relation to lives and property.

An example of the safe use of explosives in a congested city district is found in Rochester, N. Y., where the bed of the old Erie Canal was blasted for a subway for interurban electric traffic. The canal bed ran through the heart of the city. About 60,000 cubic yards of rock were excavated. Drilling and blasting went right down to the very foundations of the standing buildings, without interfering with street and bridge traffic. Du Pont Explosives—53,047 pounds of du Pont 40% and 1,050 pounds of du Pont 50% gelatin dynamite—were used on the job. Damage was sustained to the extent of *four window panes*.

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Explosives Department
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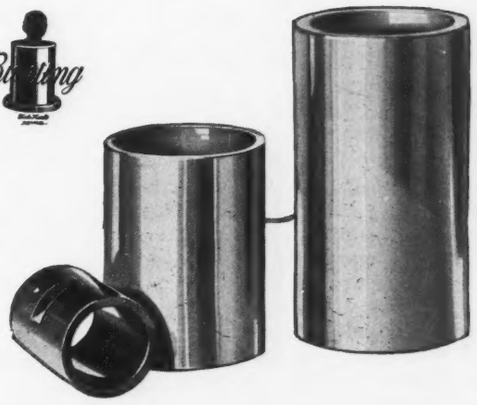

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SAN FRANCISCO
198 Second St.
Douglas 6245

PETROLEUM

(*Continued from page 149*)

except under special circumstances, as the products obtained are difficult to refine in the ordinary manner and the commercial operations of today are almost entirely limited to liquid phase apparatus.

The usual stock handled in cracking is that distillate known as gas oil, which is a relatively cheap product and which, by being put through this operation will yield 30 to 35 per cent gasoline in one run, and from 50 to 60 per cent of gasoline, if the unconverted portions are again treated.

The importance of cracking is obvious and there is an enormous amount of development work going on at the present time to improve existing apparatus and obtain greater yields of gasoline and lower costs of operation.

Broadly viewing the general construction of a refinery it will be noted that the main equipment is seldom built under cover and usually extends over a considerable amount of ground with individual buildings for the boiler plant, pump house, office, etc. Reasonable space is provided between stills, tanks and other equipment to reduce the fire hazard which is always present.

It is also customary to place retaining walls or dikes between various sections of the plant and between tanks so that in case of a spill or fire, there will be an opportunity to limit the conflagration.

The various grades of oil in a refinery are transferred by pipe lines and pump stations or houses which are so arranged as to be able to handle the connections from a great many tanks with a few pumps. They are similar to a telephone exchange where all the wires are brought into a central board and in this case the valves in the pump manifolds take the place of the extension plugs and permit the putting of a pump on any kind of service.

Reviewing very briefly the operation of a refinery, the crude is either brought to the plant by pipe line or ship and is pumped into the main storage tanks. It is drawn from this storage and placed in smaller tanks which serve the crude stills. The oil is then distilled. The first overhead distillates, which consist of gasoline, kerosene and gas oil, are segregated in the run-down tanks where the gasoline and kerosene are held for redistillation and chemical treatment while the gas oil is pumped to storage.

The residuum in the crude stills may be drawn off and sent to storage as fuel oil, or it may be further reduced or "coked." If this oil is coked, it is pumped into coke stills where it is subjected to a dry distillation. The results of this distillation being gas oil and naphtha or heavy gasoline as an overhead product, and if the crude contains lubricating stock, the lubricants and the wax will also be obtained as an overhead distillate. The residuum in the still will be petroleum coke, which is used in the manufacture of carbon products or for fuel.

The wax distillate which is about the last part of the lubricating oils to distill over, is then sent to the wax plant where it is chilled and the wax separated from it by filtration.

The separated lubricants which have been purified by chemical treatment are then pumped to the compounding plant where they are mixed in various proportions to produce commercial lubricants while the wax is purified and cast into cakes.

The greases and other similar products, are separated from the lubricating distillates and also handled in the compounding plant.

If the refinery contains a cracking plant, the gas oil which has been produced, both in the coking operation and the initial distillation of the crude itself, is distilled under pressure and an additional amount of gasoline and sometimes kerosene is produced, the residuum from the operation being fuel oil.

The products from all operations are tested, classified and sent to storage, from whence they are drawn as needed for shipment to consumers, bearing their respective trade names and brands.

In this article, a very brief outline has been given of the methods of obtaining petroleum and of the equipment used in the manufacture of its products. In the attempt to present a picture of a great industry to the reader, it is hoped that this will be viewed in a charitable light and if it has brought out the fact that this industry is not only great but comparatively new and expanding at an enormous rate, it will have served its purpose. For this means that there are vast opportunities for men of engineering training and ability and it is hoped that the few facts set forth may be of interest to graduates of engineering courses and lead them into an industry where technical men are needed and where their efforts will be of economic value.

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A Memo for Roads Scholars

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OUTLAST THE BONDS

NATIONAL PAVING BRICK MFRS. ASSN., CLEVELAND, O.

ENGINEERING ETHICS IN FINANCE

(*Continued from page 133*)

be clear upon all cases in which he is called upon to pass and that he render only such assurances as he feels adequately well informed to give. Should a particular enterprise which he is called upon to report, be one which he shall have some personal affiliation that might influence his judgment or impair the disinterested quality of his service, it is his duty to inform his employers of such conditions. He will at all times remain aware of the realization that should any information, which he shall render, be contrary to the actual circumstances and lead to misfortune to the firm upon which he reports, that this failure will reflect upon the soundness and high standing of his own employing firm. Although the securities in the form of stocks or bonds have been issued and completely sold to the investing public, the failure or partial misfortune of any enterprise will send back ill favor upon the firm offering the securities of the unfortunate concern.

Should the reports of the financial and engineering analyses of an enterprise be favorable to the lending of financial assistance, arrangements are made to provide for the raising of capital. In the due course of time suitable bond or stock certificates make their appearance and are sold to the investing public through the channels of the financial firm's organization. For the most part these securities are purchased by individuals who are personally uninformed as to the soundness of the concern to which they are lending their funds. The salesmen conducting the security transactions are in themselves without knowledge of the exact status of the undertaking their salesmanship tends to promote. Security salesman and investing public alike look to the soundness of policy and ability of the individuals who have been charged with the investigation of industrial undertakings. The engineer, holding a prominent place in the determination of industrial soundness is obligated in no small way to that large class of people whose confidence and trust are placed in the securities which his action often makes possible. He will allow no decision of his to lead to the issuing of securities for questionable enterprises. His statements must always be ones of fact, to salesman or purchaser, and must be carefully kept free from misleading suggestions. It shall be his duty to include in his report an outline of unfavorable as well as favorable factors.

Thirdly, there exists a clearly defined responsibility of the engineer to the firm which he inspects and advises. Supposedly a company desirous of financial aid is in a position to judge of the measure of success it believes the future to hold for it. Unfortunately the natural element of ambition and the customary attributes of business policies make companies poor judges of themselves. The processes used in manufacture and the methods utilized in their own enterprises appear too often to be ideal to themselves. The responsibility for seeing an industrial enterprise in its true perspective rests with the engineer as an impartial observer. His duties do not end once financial aid is granted for an industry. Continual oversight in all matters to which engineering knowledge is applicable makes his obligation a current one. His co-operation with the technical men of the individual firm's own organization, his exchange of general information and experience with fellow engineers and his frequent study of his secondary client's problems are requisite if his task is to be well done.

Finally, there is the indirect obligation which pertains to the widely separated companies and individuals who utilize the products made by the firm under his engineering supervision. It may be regarded to be outside the scope of a financial engineer's activity to exercise oversight over the sale and distribution of a financed company's products, but there is no more important consideration to which ethical reasoning can be attached than that which deals with such well defined business transactions as are conducted between an industrial manufacturing concern and the users of its products. A great measure of success for a company rests upon its business dealings being beneficial to its customers as well as to itself, and, as far as engineering factors are involved, the soundness of policy of any industrial establishment can be controlled to remarkable advantage by consulting engineers. That the qualifications and standards of its products are of sufficiently high quality, that consumers' demands are met as completely as possible and that

(*Continued on page 160*)

Business Opportunities for Engineers

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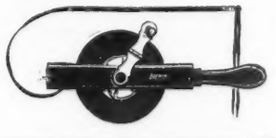

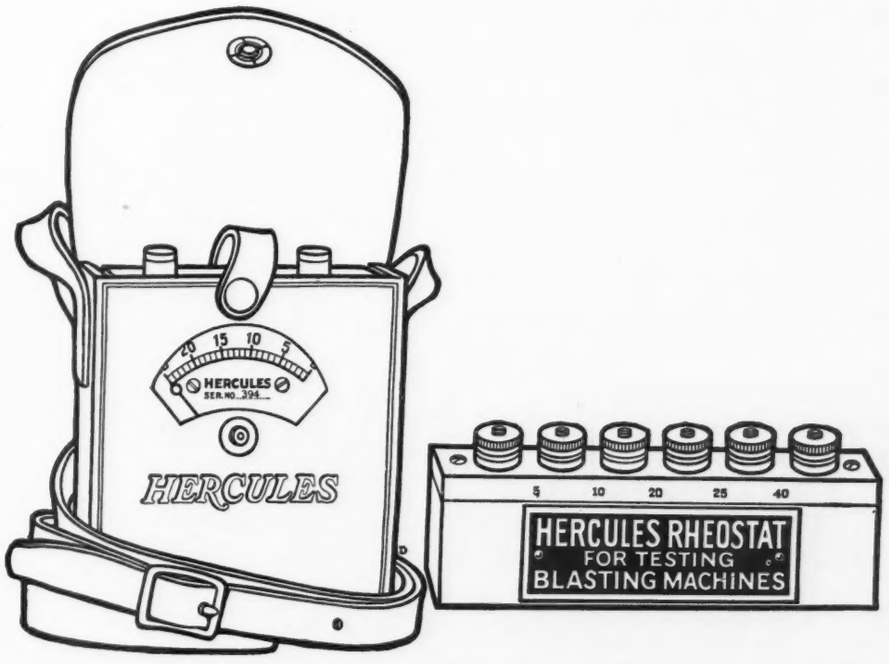

The Responsibility Is Partly Yours

WE take unusual precautions in the manufacture and testing of our electric blasting caps, often using an X-ray to check the adjustment of the minute platinum-iridium bridge and to detect any faults, the evidence of which would be destroyed in the usual method of testing caps by shooting them.

But, important as it is, the use of reliable detonators does not remove your responsibility of taking certain simple but necessary precautions when firing shots by electricity. Among these precautions are the galvanometer and rheostat tests.

Breaks, short circuits, or faulty connections can be easily detected and located with a Hercules galvanometer before an attempt is made to fire a shot. This helps to prevent misfires and saves both time and money.

The Hercules rheostat is a handy and inexpensive little instrument with which the capacity of blasting machines can be quickly tested in the field.

It will pay you to be sure that your blasting equipment includes the necessary number of Hercules galvanometers and rheostats.

HERCULES POWDER COMPANY

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Wilmington, Del.

ENGINEERING ETHICS IN FINANCE

(*Continued from page 158*)

their problems be given adequate consideration is of importance to financial and financing firms alike. To the financial engineer, therefore, there falls the secondary duty of influencing the ethical attitude of those companies to which his own firm has seen fit to offer financial assistance.

To these four arbitrarily defined classes,—to his firm, to the investing public, to the particular industry under investigation and to industries closely allied to it, the financial engineer finds himself called upon to render service far in excess of that provided by his engineering training. Through the medium of finance the engineering profession is very directly connected with public service. Because of this primary connection as advisor to the many whose support perhaps may depend upon the wise investment of their resources, the engineer to financial firms is capable of giving great assistance. By incorporating into his understanding of scientific principles, an equal recognition of ethical principles the breadth of his value is inestimably enhanced.

In the preceding presentation several ways have been mentioned in which ethics might be practically applied to engineering finance. These are but a few of many which a sound appreciation of social needs places in the path of the professional engineer. Their number cannot remain fixed. They must increase with each additional generation, for each generation is heir to a richer inheritance in knowledge from the past and with it, is under greater obligation to the future.

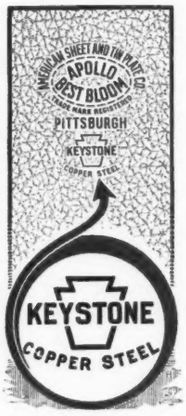
An education should be an effort to grasp the meaning of this vast inheritance, to accept in trust as much of it as is capable of being understood and to bequeath it to the succeeding generation enriched rather than depleted. To the engineer in finance there falls the opportunity to utilize the ethical as well as the engineering attainment of the past to the acknowledged benefit of the present and future.

EVERY engineer should know APOLLO Best Bloom and Apollo-Keystone Galvanized Sheets, American Bessemer and Open Hearth Steel Sheets; and KEYSTONE Copper Steel

Rust-resisting Black and Galvanized

SHEETS

We manufacture SHEET AND TIN MILL PRODUCTS for all purposes—Black Sheets, Galvanized Sheets, Corrugated Sheets, Formed Roofing and Siding Products, Galvanized Tank, Culvert and Flume Stock, Special Sheets for stamping, Stove and Range Sheets, Automobile Sheets, Electrical Sheets, Roofing Tin Plates, Bright Tin Plates, Black Plate, Etc. Sold by leading metal merchants. KEYSTONE quality is of particular interest to you. Send for booklet.



AMERICAN SHEET AND TIN PLATE COMPANY, Frick Bldg., Pittsburgh, Pa.

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TRADE MARK.

Incorporated 1884

The Standard for Rubber Insulation

FOR 45 years the name "Okonite" has stood for the highest quality of Electrical Insulation for Wires and Cables.

"Okonite" itself is a rubber compound never containing less than 30% by weight [over 60% by volume] of high grade Para Rubber with absolutely no admixtures or substitutes.

All products bearing the Okonite trademark carry with them our unconditional guarantee of excellence and unvarying reliability.

Okonite is made in but one grade.

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VAC-M Arresters Will Protect Fire Alarm Apparatus

against lightning and other electrical disturbances.

Here's what a chief who has them in service has to say:

"I would not do without them"; another writes, "More than satisfactory"; a third, "Have never had a fuse blown from lightning or high tension current"; another, "A trouble saver"; still another chief writes, "It has saved us money—fine results"; and another chief writes, "The installation has been very satisfactory. We have standardized on this equipment, and will equip any future installations in the same manner," etc.

The National Electric Specialty Co.

Toledo, Ohio

GOOD LIGHTING OF INDUSTRIAL PLANTS SECURES SAFETY AND EFFICIENCY.

The Code of Lighting for factories, mills and other work places of the State of New Jersey makes excellent recommendations of daylight for the proper lighting of industrial buildings.

Adequate daylight facilities through large window areas, together with light, cheerful surroundings, are highly desirable and necessary features in every work place, and they should be supplied through the necessary channels, not only from the humane standpoint, but also from the viewpoint of maximum plant efficiency.

Importance of Daylight.

The unusual attention to gas and electric lighting in factories, mills and other work places during the past few years; the perfection of various lamps and auxiliaries, by means of which an improved quality and quantity of lighting effects are obtained; and the care which has been devoted to increasing the efficiency in various industrial apparatus—all go to emphasize the many advantages and economies that result from vital and adequate window space, as a means for daylight in the proper quantities, and in the right direction during those portions of the day when it is available.

Three Considerations.

Three important considerations of any lighting method are sufficiency, continuity and diffusion, with respect to the daylight illumination of interiors. Sufficiency demands adequate window area; continuity requires (a) large enough window area for use on reasonably dark days, (b) means for reducing the illumination when excessive, due to direct sunshine, and supplementing lighting equipment for use on particularly dark days, and especially towards the close of winter days, (c) diffusion demands interior decorations that are as light in color as practicable for ceilings and upper portions of walls, and of a dull or matt finish, in order that the light which enters the windows or that which is produced by lamps may not be absorbed and lost on the first object that it strikes; but that it may be returned by reflection and thus be used over and over again.

Diffusion also requires that the various sources of light, whether windows, skylights or lamps, be well distributed about the space to be lighted. Light colored surroundings as here suggested result in marked economy, but their main object is perhaps not so much economy as to obtain results that will be satisfactory to the human eye.

Requirements for natural lighting:

1. The light should be adequate for each employe.
2. The windows should be so spaced and located that daylight is fairly uniform over the working area.
3. The intensities of daylight should be such that artificial light will be required only during those portions of the day when it would naturally be considered necessary.
4. The windows should provide a quality of daylight which will avoid a glare, due to the sun's rays, and light from the sky shining directly into the eye, or where this does not prove to be the case at all parts of the day, window shades or other means should be available to make this end possible.

As will be noticed in the above recommendations, large windows and proper diffusion of daylight are urged, in order to meet the demands of daylight lighting.

Shades may be eliminated and most efficient lighting obtained by the use of Factrolite Glass.

If interested in the distribution of light through Factrolite, we will send you a copy of Laboratory Report—"Factrolited."

MISSISSIPPI WIRE GLASS CO.,
220 Fifth Avenue,
St. Louis. New York. Chicago.

A sound basis for accurate measurements

WHEN you stop to consider what machinists' tools mean to the various metal working industries, their importance becomes apparent.

In nearly every modern shop, precision tools are invaluable aids in reducing time. They permit metal products made by different manufacturers, to be assembled with unerring certainty and at greatly reduced cost.

Sooner or later you will need to know about the different machinists' precision tools. Why not write for Brown & Sharpe Small Tool Catalog No. 29 and examine the line of 2000 tools—every one of importance in reducing time?

BROWN & SHARPE MFG. CO.
Providence, R. I., U. S. A.

ONE OF MANY NEW TOOLS SHOWN IN CATALOG No. 29

RECENT BOOKS

(*Continued from page 145*)

A compendium of the results of X-ray research in all countries from Roentgen's time to the present day. Author is professor of physics in Hessische Ludwigs-Universitet, Giessen, Germany.

CIVIL ENGINEERING

Emergency Water Supplies for Military, Agricultural and Colonial Purposes. Based on experience of the Mediterranean Expeditionary Force. . . . By A. Beeby Thompson. London: Crosby, Lockwood & Son; New York: D. Van Nostrand Co., 1924. 180 p.

During the World War there grew up an urgent need for developing emergency water supplies, and one of the surprises, says the author, was the extent to which driven wells could be employed. It is with this type of water engineering that the book mainly deals.

Marine Structures: Their Deterioration and Preservation, by William G. Atwood and A. A. Johnson. Washington, D. C.: The National Research Council, 1924. 534 p.

This report presents the results of work done by the Committee on Marine Piling Investigations of the Division of Engineering and Industrial Research of the National Research Council. Although not presented as an exhaustive study, the report deals in thorough fashion with the animal enemies of underwater structures and means of protection against them, with extensive consideration of local conditions in various harbors from Maine to Manila.

FUEL

Pulverised Fuel, Colloidal Fuel, Fuel Economy, and Smokeless Combustion, by L. C. Harvey. London: MacDonald & Evans, 1924. 466 p.

Author investigated American practice during the war, for the British Fuel Research Board. His report at that time and a paper before the Iron and Steel Institute form the groundwork of this book. Chapters are included on the use of pulverised fuel in metallurgical industries, in locomotive firing and on ships. Extensive bibliography.

Pulverised Fuel: A Practical Handbook, by W. F. Goodrich. London: Griffin; Phila.: Lippincott, 1924. 215 p.

"Prepared not as a scientific treatise, but rather as a practical and concise handbook." Author, who made personal investigation of the subject in the United States and other countries, reports especially upon United States, French, British and Australian practice. One chapter on fuels suitable for use in pulverised form.

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save time—error—calculation

Engineers and contractors know that BUFF performance is accurate and sure—on all sorts of work from running location lines to giving "neat lines" on important bridgework—without having to adjust the transit once.

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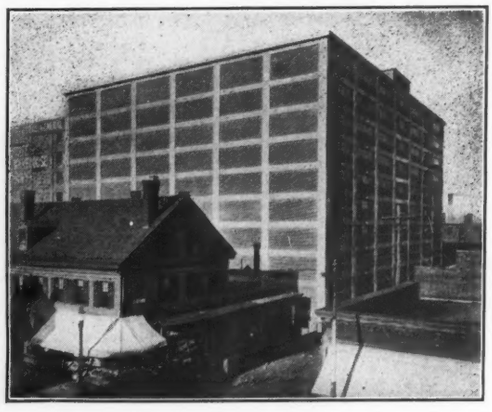

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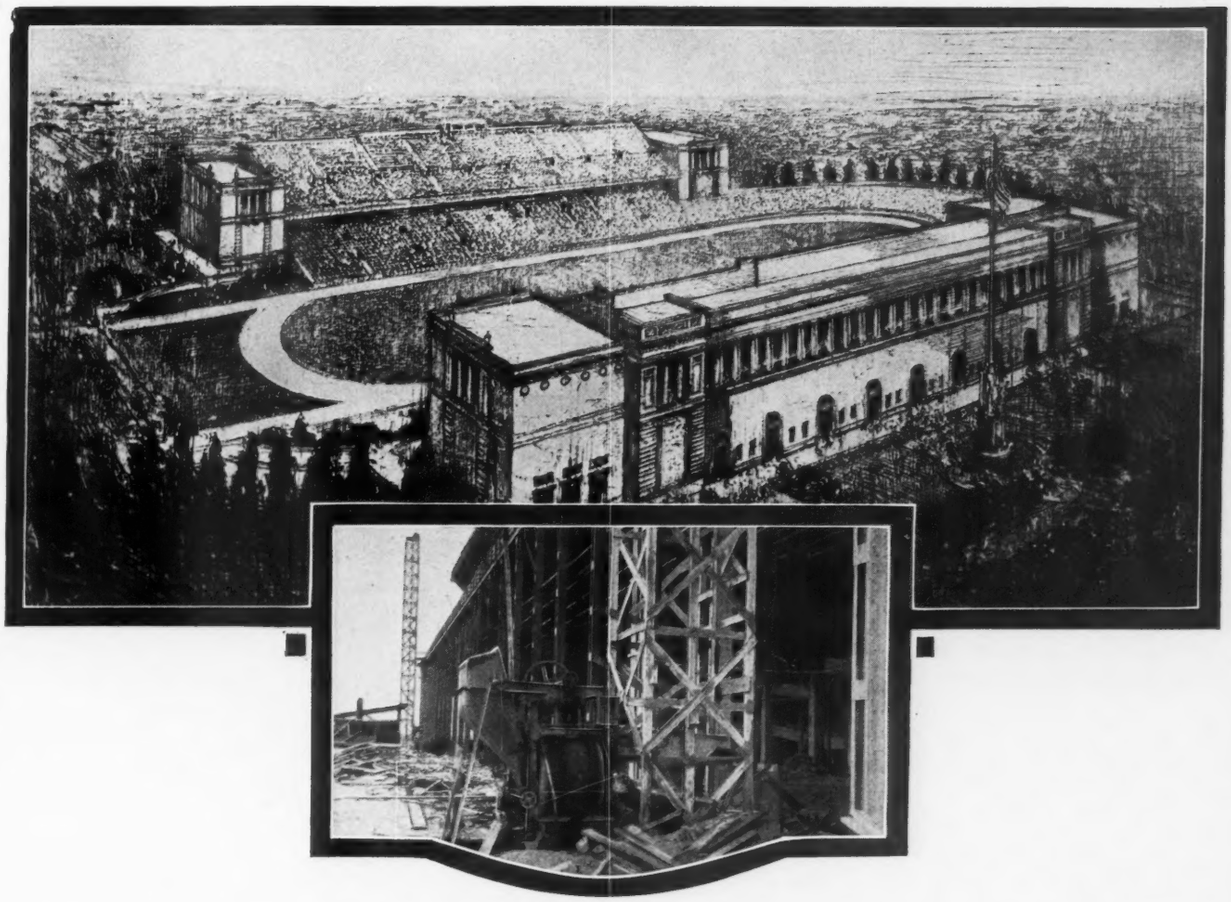

Illinois Stadium and Koehring

ILLINOIS Memorial Stadium, one of the mightiest arenas built to accommodate the ever increasing throngs of football enthusiasts stands completed, an awe-inspiring, peerless monument to Illinois spirit. Covering eight acres, located on a 56 acre field, it has a present seating capacity of over 60,000, two-thirds of which are within the limits of the goal posts. The enclosure of both ends will bring the capacity to 120,000 seats—a truly gargantuan achievement. Each side is 546 feet long and the top is 112 feet above the playing field.

Twenty thousand cubic yards of concrete mixed in Koehring Construction Mixers became transformed into enduring stone foundations, ramps, bannisters, walls, and seats in this remarkable football stadium.

On notable construction work, in every section of the country, Koehring concrete mixers are found contributing their unmarked but highly important part.

"Concrete—Its Manufacture and Use", now in its fourth edition, is a 207 page treatise on the uses of concrete, including 26 pages of tables of quantities of materials required in concrete paving work. To engineering students, faculty members and others interested we shall gladly send a copy on request.

KOEHRING COMPANY
MILWAUKEE WISCONSIN

Manufacturers of Pavers, Mixers—Gasoline Cranes, Draglines, Shovels

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THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY offers courses each of four years' duration, in Civil, Mechanical and Electrical Engineering; Naval Architecture and Marine Engineering; Mining Engineering and Metallurgy, and Geology and Geological Engineering; Architecture and Architectural Engineering; Chemistry, Chemical Engineering and Electrochemical Engineering; Biology and Public Health, and Sanitary Engineering; Physics, General Science and General Engineering; and in Engineering Administration. These courses lead to the Degree of Bachelor of Science.

To be admitted to the first-year class, applicants must have attained the age of seventeen years, and must satisfactorily fulfill entrance requirements in Algebra, Plane and Solid Geometry, Trigonometry, Physics, Chemistry, English, History, and French or German and one elective subject. Examinations are required in all subjects except Chemistry, History and the elective, the requirements for which are fulfilled by the presentation of satisfactory certificates. A division of these entrance subjects between different examination periods is permitted.

Entrance examinations are held at the Institute in September. In June, applicants will be examined by the College Entrance Examination Board in Boston, New York, Philadelphia, Chicago, and many other cities in America and Europe. A circular stating times and places is issued in advance by the College Board.

Graduates of colleges and scientific schools of collegiate grade, and in general all applicants presenting satisfactory certificates showing work done at another college corresponding to at least one year's work at the Institute, are admitted, without examination, to such advanced standing as is warranted by their previous training.

Graduate courses leading to the degrees of Master of Science, Master in Architecture, Doctor of Philosophy and Doctor of Science are also offered. Special Research Laboratories of Physical Chemistry, Applied Chemistry and Science have been established.

PUBLICATIONS

Bulletins of General Information, Courses of Study, Summer Session, Advanced Study and Research; and the Report of the President and the Treasurer.

Any of the above-named publications will be mailed free on application.

For information, address

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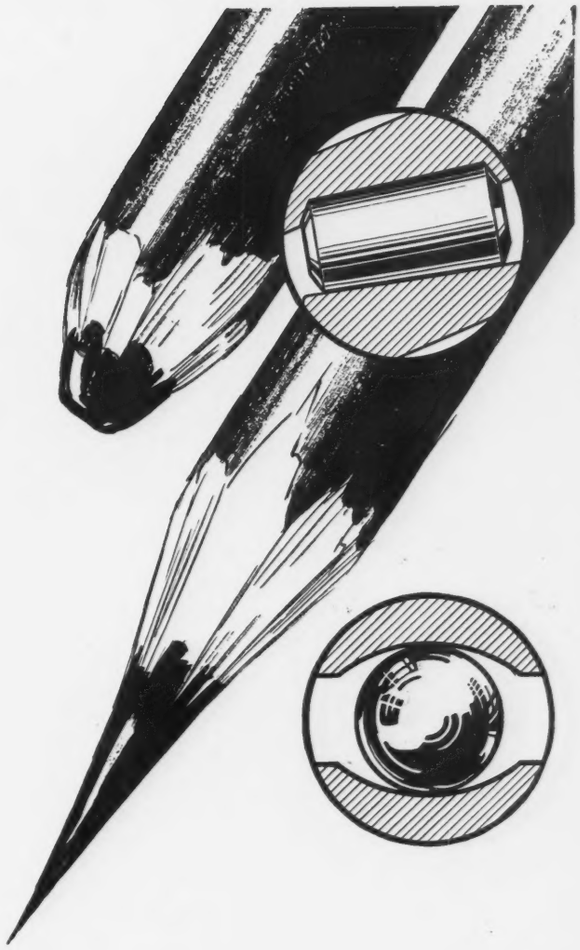

THE surest thing about a pencil with a fine, long point is that the fine, long point will soon wear off. Five minutes of rapid note-taking, and you're down to where the point is broad, and *there* the lead lasts much longer.

Here, in principle, you have a key to the superiority of a roller over a ball bearing.

Two surfaces, separated by a ball, must rest upon points in the circumference of the ball. They rest upon points because there's nothing else in the circumference of a perfect ball but points.

Two surfaces that are separated by rollers, however, rest upon the broad length of the surface of the rollers.

Although made of steel instead of graphite, and thus infinitely more enduring, the difference in life between a roller bearing and a ball bearing is nevertheless typified by the sharp vs. dulled pencil point. The broader the surface over which the load is distributed, the less rapid the wear—and the longer the life of the bearing.

Timken Bearings, in addition to being roller bearings are also *tapered* roller bearings. Because of the taper, they withstand the loads which are called "end thrust," as well as those directly at right angles to the axis in which the bearing is mounted, called "radial load." Only tapered bearings have the capacity in one bearing to withstand both these loads.

The Timken Roller Bearing Company
CANTON, OHIO

TIMKEN
Tapered
ROLLER BEARINGS

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Thomas A. Edison and Charles P. Steinmetz in the Schenectady laboratories of the General Electric Company, where Dr. Steinmetz did his great work

Steinmetz

The spirit of Dr. Steinmetz kept his frail body alive. It clothed him with surpassing power; he tamed the lightning and discharged the first artificial thunderbolt.

Great honors came to him, yet he will be remembered not for what he received, but for what he gave. Humanity will share forever in the profit of his research. This is the reward of the scientist, this is enduring glory.

Emerson tells how the mass of men worry themselves into nameless graves, while now and then a great, unselfish soul forgets himself into immortality. One of the most inspiring influences in the life of a modern corporation is the selfless work of the scientists in the laboratories, which it provides for their research.

If you are interested to learn more about what electricity is doing, write for Reprint No. AR391 containing a complete set of these advertisements.

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